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ABSTRACT

Demand projections indicate that Oahu's natural ground water supply will be fully developed by the year 2000. Supplementary water resources will need to be developed in keeping with the growth of the economy and population. The author, chairman of the Honolulu Board of Water Supply, authoritatively discusses types of ground water in Hawaii, and areas of interest in water development throughout the Islands. This is followed by an in-depth historical accounting of Oahu's water supply system. The present water resources, population, land use situation, and projects for the future are examined. The Board of Water Supply, which has amply provided Oahu with high quality water, has carried out its responsibilities inefficiently. Management, in terms of utilizing computer technology, is indicated to deal with increasing problems. The issue of whether to combine water supply operations with sewerage functions is presented. Institutional responses to water supply needs, desalination, water recycling and treatment, and energy are other topics thoroughly treated. Although technological innovations can be used to increase supply, specific development projects, conservation measures, and institutional reform are recommended to meet Oahu's water supply needs beyond the year 2020. An extensive bibliography of published and unpublished materials is included. (BP)

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ABSTRACT

OAHU, HAWAII'S WATER SUPPLY: 1848 - 2020 A.D.

By

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Dissertation Submitted in Partial Fulfillment of
the Requirements for the Degree of
Doctor of Philosophy

Walden University

July, 1975

SE 019 469

ABSTRACT

During the first three quarters of the Twentieth Century, Oahu's water resource managers and other public policy decision makers applied innovative technology and enacted institutional reforms in order to provide the Island community with an ample supply of fresh water.

Demand projections indicate that Oahu's natural ground water supply will be fully developed by the end of the Twentieth Century. This potential environmental limit to the growth of Oahu's economy and population may be extended by developing supplementary water resources as follows:

1. The exchange of treated waste water for high quality water presently used for irrigation.
2. The development of the springs and streams that empty into Pearl Harbor.
3. The development of certain surface streams for water supply and ground water recharge.
4. The demineralization of brackish water.
5. The demineralization of sea water (if necessary).
6. The reclamation of waste water for domestic use (if necessary).

While technological innovations may be used to augment supply, conservation measures should be implemented to reduce the demand for water resources. Conservation

measures include public information programs and the introduction of water saving techniques to agriculture, industry and in the home.

Institutional changes should be implemented to coordinate Statewide and Island-wide water supply research and development programs. Institutional reforms would facilitate the community's response to an increasingly challenging water resources situation.

A combination of specific development projects, conservation measures and institutional reforms are recommended to meet Oahu's water supply needs beyond the year 2020.

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PREFACE

The writer, as Chairman of the Honolulu Board of Water Supply, has become deeply concerned about the future of water supply on Oahu. The Island of Oahu has experienced unprecedented economic and population growth in the Twentieth Century. The demand for high quality water has increased rapidly. Yet the Island's natural water resources are known to be limited.

The ground water supply, which planners believe will be fully developed by the year 2000, constitutes an environmental limit to growth on Oahu. This limit may be extended through the judicious application of such water resource technology as desalination and waste water recycling. The use of such technology would augment the natural supply of fresh water. However, unless there are significant technological breakthroughs, each additional increment of supply will be obtained at an ever-increasing unit cost. Since Oahu's capital resources, energy resources and material resources are finite, the community may elect to withhold the allocation of resources from the development of additional water supplies in favor of meeting other vital public needs. In such a situation, the conservation of water resources would become increasingly important to the welfare of the community.

During the first three quarters of the Twentieth Century, Oahu's water resource managers and other public policy decision makers applied innovative technology and enacted institutional reforms in order to provide the Island community with an ample supply of fresh water. In this dissertation the writer will examine the history of water supply management on Oahu from the mid-Nineteenth Century to the present. The writer will devote special attention to the current water supply and demand situation, and will describe the technological and institutional options that are available to decision makers and the community as a whole. In the concluding chapter, the writer will recommend a combination of specific technological measures, conservation measures and institutional reforms intended to enable water resource managers to meet Oahu's water supply needs beyond the year 2020.

Chapter 1

WATER RESOURCES IN HAWAII

The history of water supply on Oahu takes place in a particular geographical setting and within a distinctive geological context. Oahu is located in the tropical zone just below the Tropic of Cancer. The Island is bisected by the 158° West Meridian, and lies approximately 2,400 miles west-southwest of San Francisco.

The Hawaiian Islands are part of an immense volcanic ridge that extends from the northwest to the southeast for 1,600 miles in the Central Pacific Ocean. Oahu itself is relatively small. Its area is 604 square miles, and an irregular coastline 150 miles in length shapes its boundaries. Oahu is composed of two mountain ranges: the Waianae Range extending for 20 miles on the western side of the Island, and the Koolau range stretching 37 miles from Kahuku Point in the north to Makapuu Point in the South. Between the two ranges lies the fertile plateau that forms the central portion of the Island.[1]

The mountain ranges, especially the Koolaus, play a critical role in Oahu's water supply. The peaks of the

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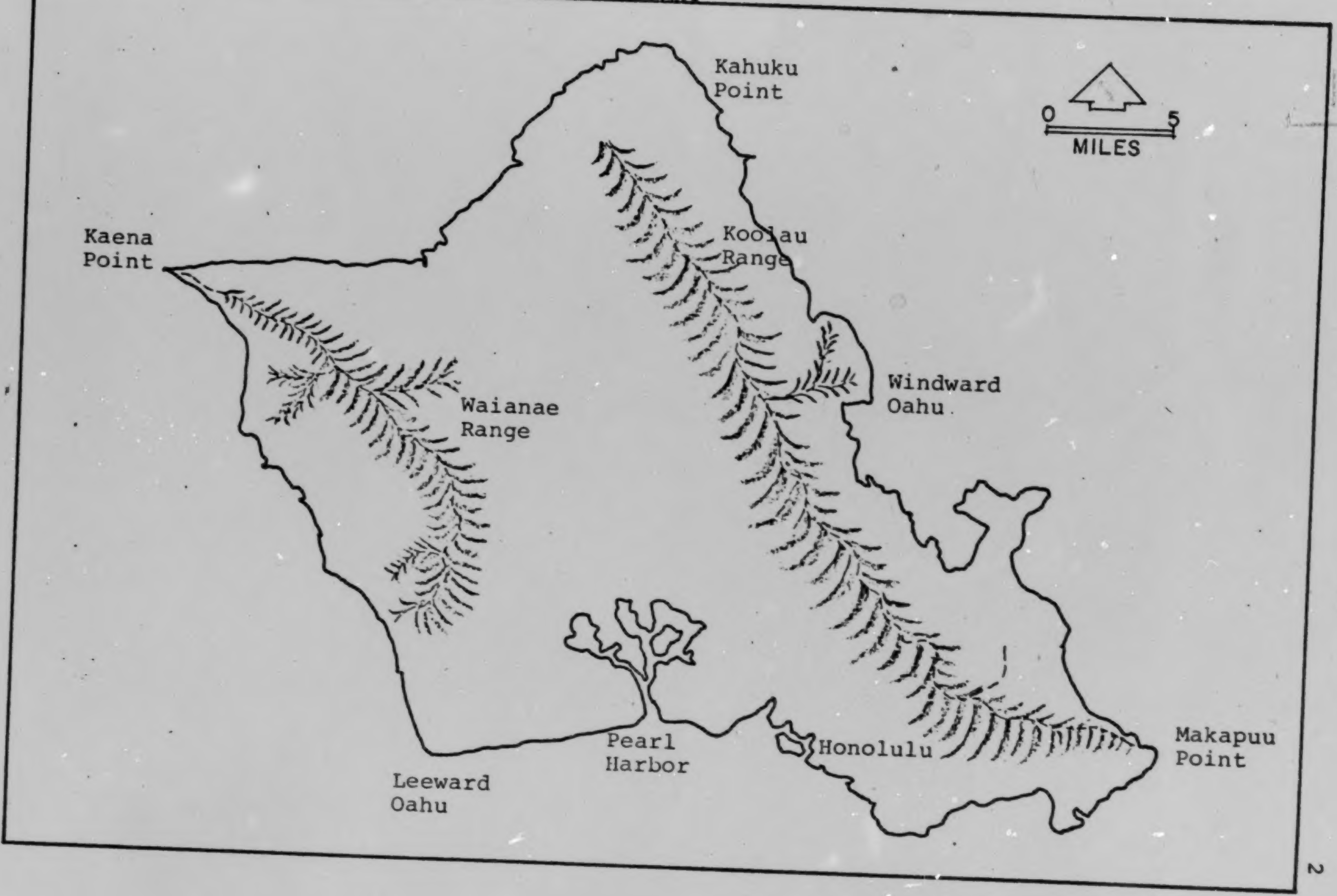
[1] Honolulu Board of Water Supply, Oahu Water Plan (Honolulu: Honolulu Board of Water Supply, 1963), p. 4.

MAP 1

OAHU


Kahuku Point
0
5
MILES
Kaena Point
Koolau Range
Windward Oahu
Waianae Range
Pearl Harbor
Honolulu
Makapuu Point
Leeward Oahu

Koolau Range rise to over 3,000 feet above sea level. The Koolaus lie athwart the direction of the prevailing trade winds. The winds carry moisture, and as they encounter the mountains the moisture is lifted, cooled and condensed into precipitation. The heaviest rainfall, averaging 300 inches per year, occurs high in the mountains. But less than fifteen miles away, along the arid leeward coasts, rainfall averages less than 20 inches per year. Thus there are extreme differences in rainfall over relatively short distances on the Island of Oahu. With rainfall as high as 300 inches per year, one might expect frequent flash flooding. But fortunately most of the volcanic rocks and residual soils that make up the Island are highly permeable.[2] Nevertheless, only about one third of the approximately two billion gallons of rain that falls on Oahu every day enters the Island's subterranean basins. About a third of the rainfall escapes as runoff to the ocean, and the other third is lost to evaporation from the ground and transpiration, the releasing of moisture from the surfaces of plants.[3]

Three types of ground water occur on Oahu. The most extensive ground water source is the basal fresh water

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[2] Ibid., p. 6.

[3] George Yuen, "Water--The Final Limiting Factor in Diversified Agriculture," speech to the Diversified Agriculture for Hawaii Conference, Princess Kaiulani Hotel, Honolulu, November 5, 1973.

"lens" which underlies most of the Island. Fresh water is slightly lighter than salt water, and the lens of fresh water floats upon the salt water that permeates the subsurface rock. From Diamond Head to Barbers Point the basal fresh water lens is held under pressure by a relatively impermeable caprock. This ground water constitutes Oahu's primary artesian water resource. In the Honolulu area fresh water rises to a height of about twenty-five feet above sea level; this phenomenon is known as the "artesian head."[4]

Artesian waters are developed by drilling wells several hundred feet through the caprock to release a bountiful flow of water under pressure. Other basal waters can be developed by drilling tunnels to skim off the surface of the fresh water lens.

A "zone of mixing" consisting of brackish water occurs in coastal areas where fresh waters and salt waters merge. When the basal fresh water supply is overdrawn, one effect is the movement inland of the zone of mixing. The saline content of this brackish water is constantly monitored to determine the extent of saline contamination of the basal fresh water lens. Ground water is in constant motion in Oahu. It percolates through the volcanic strata, enters the lens, accumulates in more or less specific

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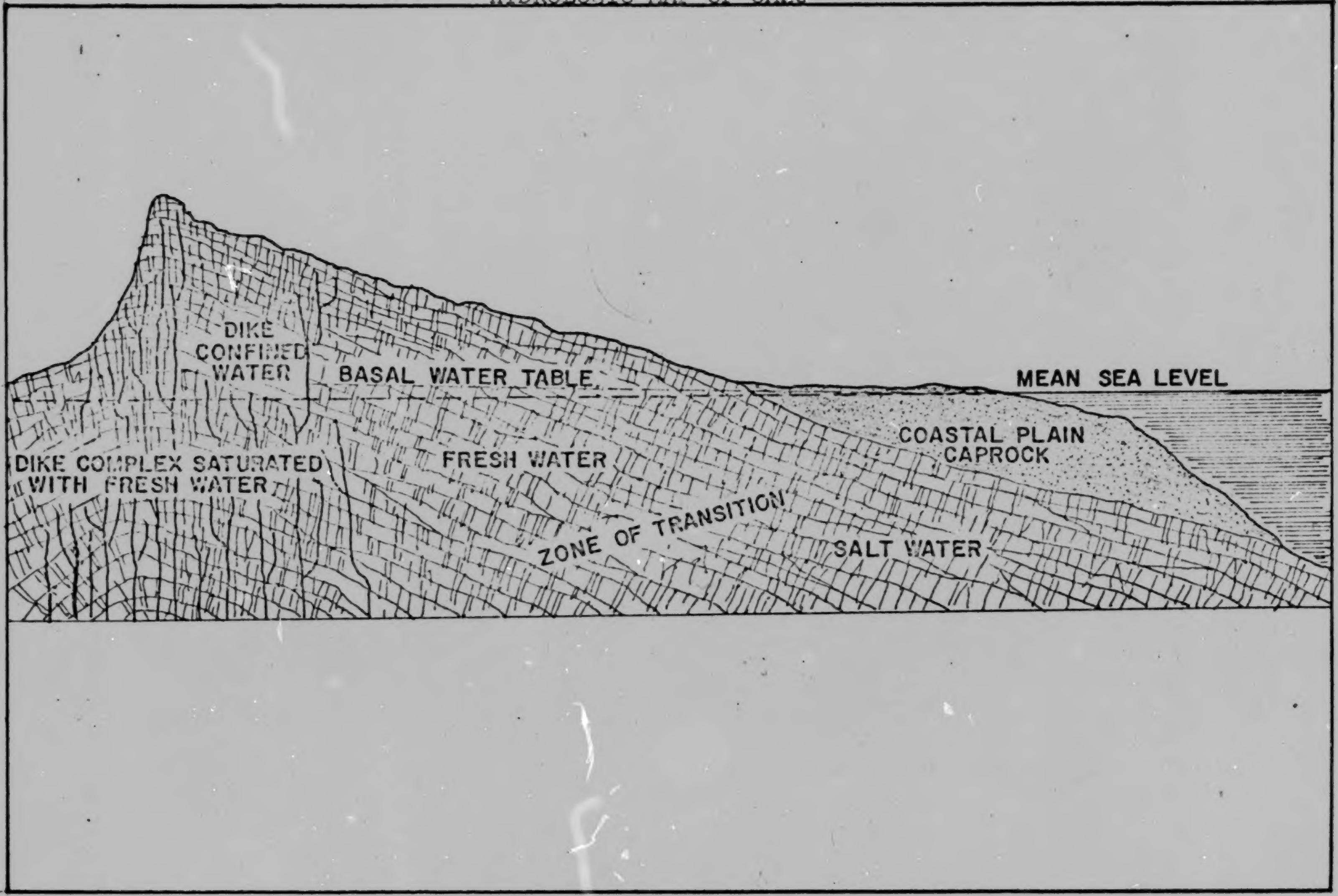
[4] Oahu Water Plan, pp. 6, 7.

MAP 2

HYDROLOGIC MAP OF OAHU


DIKE CONFINED WATER
BASAL WATER TABLE
MEAN SEA LEVEL
COASTAL PLAIN CAPROCK
DIKE COMPLEX SATURATED WITH FRESH WATER
FRESH WATER
ZONE OF TRANSITION
SALT WATER

artesian basins, and moves by innumerable roundabout routes toward the zone of mixing and the sea.

A second ground water source on Oahu consists of fresh water that is confined between walls of impermeable rock within the structure of the mountain ranges. This "dike water," or "high level water," is an important local source of supply in some parts of Oahu. It can be developed by tunnelling into a mountain, piercing a "dike" of impermeable rock, and releasing the fresh waters impounded within. One advantage of dike water is that it occurs above sea level and is free from salt water encroachment.[5] The least significant type of ground water on Oahu is held up, or "perched" upon horizontal beds of impermeable rock. Oahu lacks important sources of perched water, although this source has been developed to solve minor supply problems.[6]

There are many streams on Oahu extending from the heavy rainfall areas in the mountains to the shoreline and the sea. Stream flows are generally flashy in nature, particularly in mountainous areas. Minimum flows consist mainly of ground water seepage and discharges from springs. But occasionally torrential flows occur as a result of heavy rains. During periods of high stream flow immense quantities of water run off to the sea. The mountainous topography, narrow valleys and typically pervious rock formations are factors which have discouraged the construction of impounding reservoirs. Although there are many small reservoirs on Oahu, there is only one relatively large one: the two billion gallon capacity storage reservoir at Wahiawa.[7]

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[5] Hawaii Water Authority, Water Resources in Hawaii (Honolulu: Hawaii Water Authority, 1959), p. 39.

[6] Ibid., p. 40.

Water resource managers are confronted with unique problems and opportunities on Oahu and the Neighbor Islands. The Neighbor Islands have much in common with Oahu in terms of shared geologic origins and similar hydrology. Yet each island has a unique character and a distinct water supply situation.

The four largest islands, Hawaii, Maui, Oahu and Kauai have abundant ground water supplies. Molokai has a smaller, but still substantial supply. But Lanai, Niihau and Kahoolawe have relatively little water. The Island of Hawaii is made up of five volcanoes that have coalesced to form the largest island of the group. With an area of approximately 4,030 square miles, the "Big Island" represents about two thirds of the State's total land surface. Annual rainfall is highly variable; from less than 10 inches along Kawaihae Bay to more than 300 inches in the mountains above Hilo. The Hamakua Coast-Hilo-Puna section of the Island is exposed to the prevailing trade winds and receives enough rainfall to lead the State in sugar production with only limited irrigation.

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[7] Ibid., p. 22. The well known reservoirs in Nuuanu Valley provide reserve storage capacity and are used to recharge ground water supplies.

Ranching is second to sugar cultivation among the Big Island's agricultural activities. Thousands of head of cattle are pastured on the large grassy areas in the drier parts of the island. Truck farming is a major activity in the Waimea plain between Kohala and Mauna Kea, and substantial areas of the Kona Coast are given over to the cultivation of coffee.[8]

In 1963 the State began a comprehensive study of the water supply situation in the South Kohala area of the Big Island. The study recommended the development of stream waters to provide for growing domestic and agricultural needs. It suggested the construction of dams to divert stream water, conveyance facilities to deliver the diverted water, storage reservoirs and a filtration plant to upgrade water quality. The South Kohala Water Development project is proceeding by stages. The State Department of Land and Natural Resources is putting together an environmental impact statement for a major phase of the project, the construction of a large dam on Kohakohau Stream.[9]

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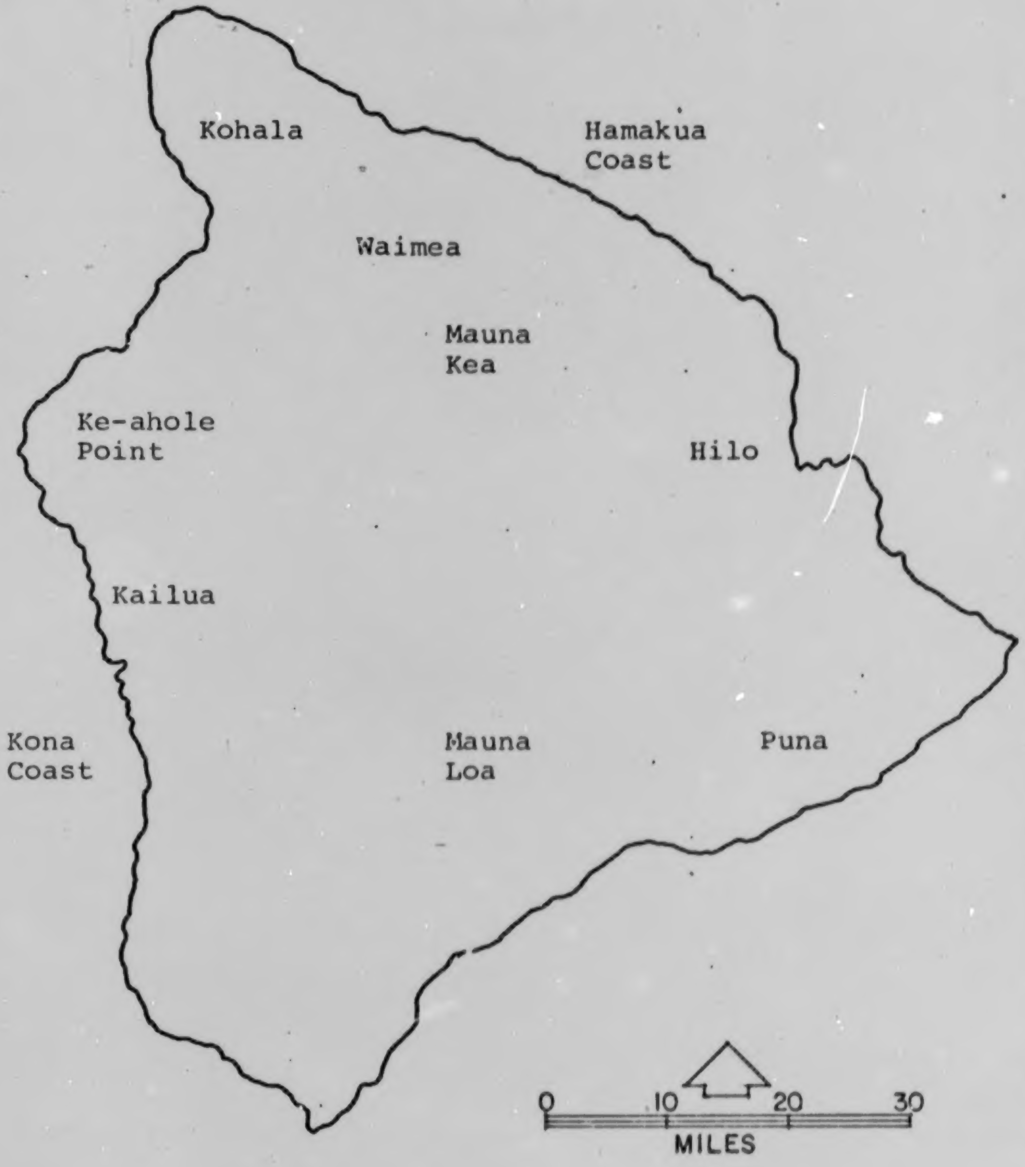
[8] U.S. Geological Survey, The Role of Groundwater in the National Water Situation (Washington, D.C.: U.S. Geological Survey, 1963), pp. 278-280.

[9] Robert T. Chuck, "Hawaii's Water Resources," paper presented at 55th Annual Conference, California Section,

MAP 3

HAWAII (THE BIG ISLAND)


Kohala
Hamakua Coast
Waimea
Mauna Kea
Ke-ahole Point
Hilo
Kailua
Kona Coast
Mauna Loa
Puna
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10
20
30
MILES

Environmentalists have objected to this dam on the grounds that the dam will present an unjustifiable safety hazard, and that the aesthetic qualities of the stream will be destroyed by the project.

Robert T. Chuck, Chief Engineer of the Division of Water and Land Development, Department of Land and Natural Resources, told the writer that the greatest challenge facing water resource managers in the coming years is that water must not become a limiting factor in the achievement of high quality growth. Water resources should be developed ahead of need, and South Kohala is badly in need of water if it is to achieve significant growth. Mr. Chuck stated that many environmentalists want to stop growth entirely, and they have seized upon water as a limiting factor. But growth is a fact of life in Hawaii. Our society should achieve quality growth rather than abandon the concept of growth entirely. Well-intentioned environmentalists who try to block all growth may well harm the interests and the quality of life of the very people they are trying to help.[10]

Another area of intense interest in water resource development on the Big Island is in the Kona district.

American Water Works Association at the Sheraton-Waikiki Hotel, Honolulu, October 16, 1974.

[10] Interview with Robert T. Chuck, Division of Water and Land Development, State Department of Land and Natural Resources, Kohakohau Dam Engineering Feasibility (Honolulu: Department of Land and Natural Resources, 1970), pp. i-vi.

Prior to 1957, when the State initiated its Kona domestic water development project, only a small portion of the Kona coast was served by a water system. Most residents depended on an antiquated "roof catchment" method for their water needs.

Engineers were fully aware that an immense basal ground water body underlies most of the Big Island. But since so much of the land area is hundreds of feet above sea level it is prohibitively expensive to develop basal ground water. Nevertheless, Department of Land and Natural Resources engineers drilled six successful wells along the Kona coast. The State, in cooperation with the Hawaii County Department of Water Supply built pumping stations, pipelines, storage tanks and automatic control systems for communities along twenty five miles of the Kona coast. The availability of ample supplies of fresh water contributed to the expansion of the tourist industry in and around Kailua, Kona, and stimulated further work on the water development project. The State has recently undertaken the construction of a 1,100 foot inclined shaft at Kahaluu, Kona, and this project is expected to provide for the water supply needs of the Kona coast for years to come.[11]

Maui, at 728 square miles, is the second largest island of the Hawaiian group. Maui consists of two extinct volcanoes joined by a broad, low isthmus. The eastern volcano, Haleakala, rises 10,025 feet above sea level, almost twice the altitude of the western volcano. The northeastern and eastern slopes of the mountains receive abundant rainfall; the leeward slopes and the isthmus are dry. Extensive sugar cultivation takes place in the isthmus. Ditches and tunnels carry water for many miles from the eastern slopes of Mount Haleakala to the sugar fields in the lowlands. Irrigation is so extensive that it is safe to conclude that more water is used on Maui than on any of the other Hawaiian Islands.[12]

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[11] Robert T. Chuck, "Hawaii's Water Resources."

A decade ago the Lahaina district consisted of several villages and small towns in a typical rural Hawaiian setting. The communities provided support for the agricultural activities in the area. But as tourism spread from Oahu to the neighbor islands, Lahaina began to realize its potential as a visitor destination area. Resort hotels, residences, golf courses and other recreational facilities developed rapidly. This unprecedented growth imposed demands for water that far exceeded the capability of the existing water supply system.

The State Department of Land and Natural Resources responded to the needs of the Lahaina district first by undertaking a study, A Water Source Development Plan for Lahaina District, in 1968, and then by implementing its

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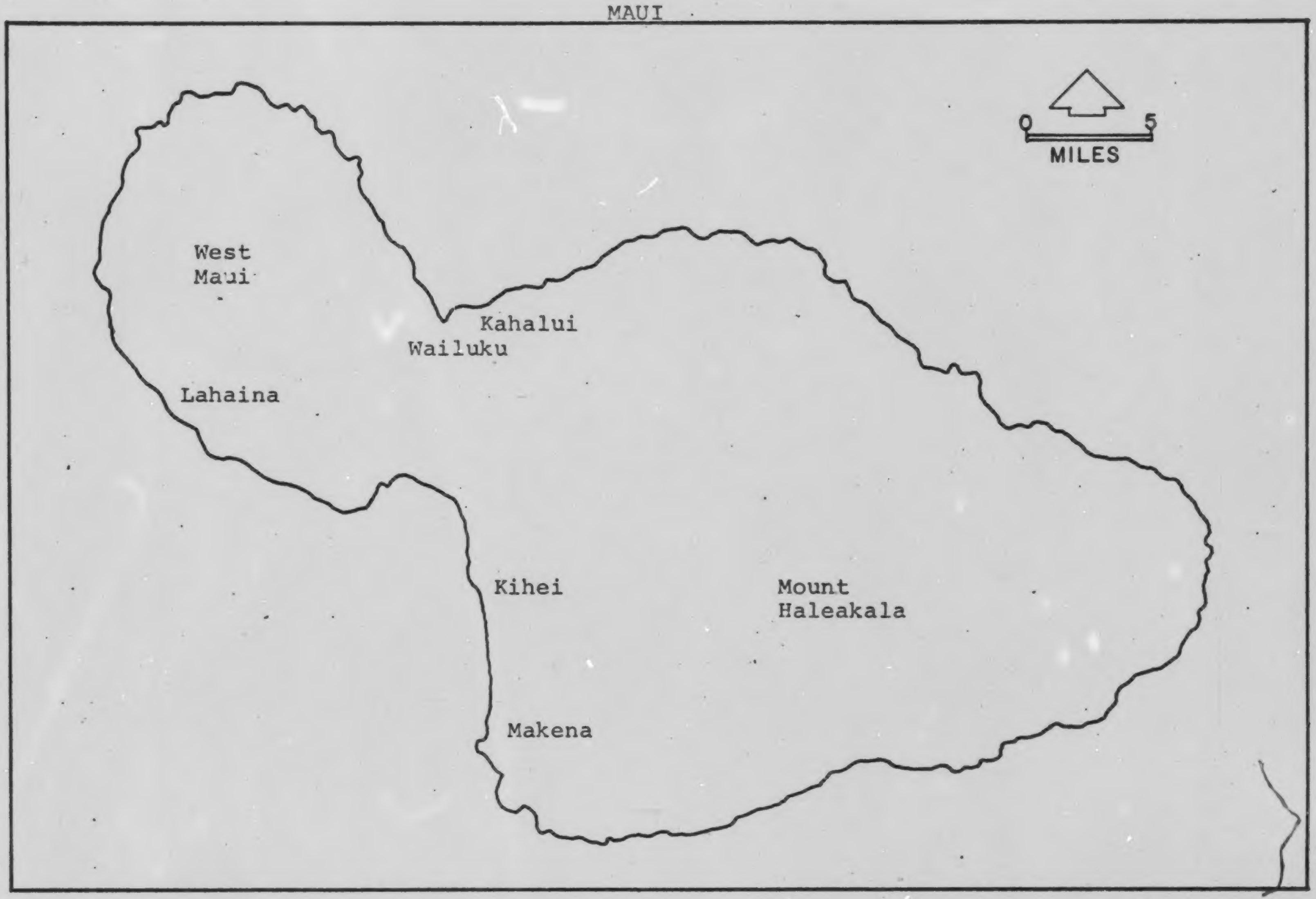
[12] U.S. Geological Survey, The Role of Groundwater in the National Water Situation, pp. 285-287.

MAP 4

MAUI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5
MILES
West
Maui
Kahalui
Wailuku
Lahaina
Kihei
Makena
Mount
Haleakala

recommendations. The Department has brought in three successful wells along the West Maui coast; pumps, storage facilities and pipelines are going into operation to meet the expanded water supply needs of the Lahaina district.[13]

The towns of Wailuku and Kahului are expected to continue to grow at a relatively slow pace. But land planning studies predict unprecedented growth for the Kihei-Makena region in leeward East Maui. The State has designated Kihei-Makena a "Visitor Destination Area," and the following chart indicates the accelerated pace of development anticipated for Kihei-Makena:

Wailuku-Kahului

Year	Population	Water Required Daily
1970	21,270	3.83 million gallons
1975	22,600	4.06 " "
1980	24,030	4.32 " "
1985	25,530	4.60 " "
1990	27,000	4.86 " "

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[13] Robert T. Chuck, "Hawaii's Water Resources"; Department of Land and Natural Resources, A Water Source Development Plan for Lahaina District (Honolulu: Department of Land and Natural Resources, 1969). The pages of this study are not numbered. However, Chapter VII, "Prospects for Water Development," is especially valuable.

Kihei-Makena

Year	Population	Water Required Daily		
1970	1,500	0.27 million gallons		
1975	4,860	0.88	"	"
1980	11,440	2.06	"	"
1985	21,630	3.89	"	"
1990	41,300	7.43	"	"[14]

In 1970, Kihei was a village, and there were only a few scattered residences between Kihei and Makena. But a number of hotels, visitor-oriented facilities and retirement residences will be built in Kihei-Makena in the next decade. In addition, the region will grow as a suburban community for Wailuku-Kahului.

Annual rainfall is only 10-15 inches in Kihei-Makena, and municipal water supplies are only adequate for present needs. The Maui County Department of Water Supply operates the domestic water supply system in Kihei, but municipal water has not yet been extended to Makena. The Maui County system's major sources of supply are the three Mokuhau wells which tap the basal ground water lens underlying Iao Valley in windward west Maui and the Iao Tunnel which develops high level, dike confined water. These sources are serving Wailuku and Kahului as well as Kihei.

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[14] Department of Land and Natural Resources, Water for Kihei-Makena (Honolulu: Department of Land and Natural Resources, 1970), p. 5.

The Department of Land and Natural Resources has recognized that water will be a limiting factor in the growth of Kihei-Makena unless additional sources of high quality water are developed and made available to the region. The Department is investigating ground water sources near Kihei, but is more optimistic about developing ample supplies at four sites in windward west Maui.[15] It is clear that water resource managers face a real challenge to provide plenty of fresh water in advance of the increasing growth in the Kihei-Makena area.

Kauai, the fourth largest of the Hawaiian group, is geologically the oldest of the major islands. Its lava flows are less permeable than those of the other islands, and its annual rainfall is exceptionally high. This combination of high rainfall and low permeability has contributed to the relative importance of surface water on the "Garden Isle."

Kauai has more streamflow in relation to rainfall than any of the other islands. Streamflow has been extensively developed for the irrigation and processing of sugarcane, and to some extent for the development of hydroelectric power. Basal fresh water underlies most of the island, although brackish ground water is a problem in some areas along the coast. Ground water supplies are generally ample and are usually reserved for domestic use.[16]

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[15] Water for Kihei-Makena, pp. 60-69.

The Island of Molokai is relatively dry. There is abundant rainfall on the windward side of the Island which is exposed to northeasterly trade winds. But the central plains, where the soil is fertile and ideal for cultivation receive less than thirty inches of rainfall per year. Lack of sufficient rainfall has limited the central area to pineapple cultivation and the pasturing of cattle. The problem on Molokai is typical in the State of Hawaii: how can the abundant resources of the windward valleys be utilized for the arid, but fertile, central plains?

In 1957 the Hawaii Water Authority began work on a five mile tunnel through the mountains in order to bring windward water to the central plain. A major part of this project was the diversion of Waikolu Stream and facilities for storing and transmitting Waikolu Valley water through the tunnel and twenty miles of distribution mains to the fields of central Molokai. The project was completed in 1969 at a cost of about $10,000,000. The Molokai tunnel brought ample supplies of water for irrigation, but for economic reasons the future of pineapple cultivation in Molokai is in considerable doubt. At the very least the

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[16] The Role of Groundwater in the National Water Situation, p. 283; Water Resources in Hawaii, pp. 83, 84; Robert T. Chuck, "Hawaii's Water Resources."

Molokai tunnel project provides enough water to make the cultivation of alternative crops a possibility.[17]

Lanai, like Molokai, is a relatively dry island. Rainfall ranges from ten to forty inches per year. There are no perennial streams; the only source of supply is ground water developed primarily from dike formations. Ground water provides for domestic needs and for dry-weather irrigation of pineapple, Lanai's principal crop. There is little opportunity for major water development on Lanai because of the limited rainfall. The demineralization of sea water was proposed by the Hawaii Water Authority in 1959 as a possible supplementary source for the future.[18]

On May 6, 1973, the State Land Use Commission reclassified 22,340 acres of conservation land on Lanai to permit the Maui County Planning Commission and the Maui County Council (the Island of Lanai is part of Maui County) to rezone the land for resort and residential use. At this writing, the Planning Commission has recommended that 124 acres of this land be rezoned for hotel and apartment construction. The County Council has not yet rezoned any of the land in question. Thus no construction has taken place. As far as water resources are concerned, the Maui County Planning Commission is convinced that resources are more than sufficient to accommodate resort and residential development in the 124 acres recommended for rezoning.[19]

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[17] The Role of Groundwater in the National Water Situation, pp. 287, 288; Water Resources in Hawaii, p. 84; Robert T. Chuck, "Hawaii's Water Resources."

[18] The Role of Groundwater in the National Water Situation, p. 285; Water Resources in Hawaii, p. 85.

The Island of Niihau is the smallest of the inhabited islands. The population numbers only a few hundred and the economy of Niihau is largely self-contained; most of the Island's agricultural products are consumed locally. Rainfall is light; there are no perennial streams and most of the basal ground water is brackish. The prospects for developing good quality water on Niihau are slight. In the unlikely event that significant growth may occur on Niihau, sea water conversion would be a possibility.[20]

The history of water supply in the Hawaiian Islands is shaped by the geographic and hydrologic factors described above. The following chapter will examine the history of water supply on Oahu and the interplay of social, political and economic conditions in the development of Oahu's water supply.

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[19] Telephone conversations with Ralph Matsuda of the Maui County Planning Department and Robert Chuck of the Division of Water and Land Development, State Department of Land and Natural Resources, on May 12, 1975, confirmed the information with regard to land use changes and water resource availability on Lanai.

[20] The Role of Groundwater in the National Water Situation, p. 289; Water Resources in Hawaii, p. 85.

Chapter 2

A HISTORY OF OAHU'S WATER SUPPLY

The following chronology is intended to place key events and processes relating to Oahu's water supply system into their historical context.

1848	The Hawaiian Monarchy begins operation of Oahu's first water supply facilities.
1879	Artesian water is discovered on Campbell Estate land in Ewa.
1893	The end of the Hawaiian Monarchy.
1898	The Republic operates Oahu's water supply system from 1894 to 1898. In 1900, the Territory assumes control of the water supply system.
1913	The Territorial Legislature turns the operation of the system over to the City and County of Honolulu.
1915	The Board of Supervisors establishes the Honolulu Water Commission to study the water supply situation. The Commission reports in 1917.
1925	The Territorial Legislature establishes the Honolulu Sewer and Water Commission (HS&WC). The HS&WC acts to prevent a water crisis.
1929	The Legislature passes the Cooke Bill establishing the Honolulu Board of Water Supply (BWS).
1930	Major Wilson relinquishes control of the water supply system to the Board of Water Supply.
1932	The City and County takes full responsibility for the operation of the sewerage system. This function remains with the City until 1974.

1941 World War II accelerates growth on Oahu and places heavy demands on the water supply system.

1944 The Halawa Valley Project goes into operation; for the first time, Honolulu received water from outside the limits of the District of Honolulu.

1953 The Territory establishes the Hawaiian Irrigation Authority (HIA).

1957 The Territory replaces the HIA with the Hawaii Water Authority (HWA).

1959 The Territorial Legislature passes Hawaii's basic ground water law.

1959 The Board of Water Supply takes over the responsibilities of the Suburban Water System. An integrated, Island-wide system becomes a possibility.

1959 Statehood, and accelerated growth for Oahu.

1961 The Division of Water and Land Development, Hawaii Department of Land and Natural Resources, becomes the State's administrative arm in the water resources field. The Hawaii Water Authority is abolished.

1971 The Board of Water Supply publishes the 2020 Plan.

1974 The Board of Water Supply undergoes reorganization.

1975 The Board of Water Supply revises the 2020 Plan.

An awareness of the life-giving qualities of fresh water was an integral part of ancient Hawaiian life. The Hawaiians built their villages where water was available, and the opening of the intricate network of canals to irrigate the taro fields was a focus of community experience and celebration. Legends recall the travels of Kane and Kanaloa, two of the most important deities, who unleashed springs and streams throughout the Islands, for the benefit of the Hawaiian people. Two famous pools on Oahu are said to have been created when Kane plunged his spear into the ground: Ka-Puka-O-Kalihi (The Water Door of Kalihi) and Ka-Wai-a-ke-Akua (the Water Provided by a God) in upper Manoa Valley.[1] In the legend of "Aukele-nui-a-Iku," a man visited the sacred pool "Kalani-i-Hau-ola," and with the help of Kane, obtained waters that brought his dead brothers back to life.[2]

There are many such stories in Hawaiian folklore. The gods of water were seen as the givers of life. They were associated with the irrigation, cultivation and harvest of taro root and the production of tapa cloth. The Hawaiian people recognized the importance of an ample supply of fresh water and they expressed this understanding through the songs, stories and legends that reflect their philosophy of life.

In order to understand Oahu's contemporary water supply situation, it is important to be aware of the Island's historical development and the role of water in Hawaii's history. This chapter will consider the following:

1. Patterns of settlement on Oahu and their relationship to water supply.

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[1] Honolulu Board of Water Supply, Pure Water for Honolulu (Honolulu: Honolulu Board of Water Supply, 1964), p. 4.

[2] Abraham Fornander, An Account of the Polynesian Race, Its Origins and Migrations (Tokyo, Japan: Charles E. Tuttle Company, 1969), p. 78.

2. Water supply crises and their amelioration through the application of technology and the reform of institutions.

3. The effects of the Depression, World War II and the postwar period upon Oahu's water supply.

In the early decades of the Nineteenth Century most of the Honolulu area was dusty and barren. A village stretched from lower Nuuanu Valley to the Harbor area around the base of present day Fort Street. People drew their water from the stream running through Nuuanu Valley, from springs in the Valley and from shallow wells in the coastal plain. By the 1830's the provisioning of the whaling ships that wintered in Honolulu harbor was the most important industry on Oahu. Fresh water was a necessity for the whaling ships, and the owners of shallow wells did a good business selling water to ship captains. But the quality of water from these wells was poor, and it was deteriorating. By 1845, community opinion demanded that some means be found to bring quantities of good quality water down from Nuuanu Valley to provide for the needs of the whalers and the beautification of the town.

In 1848, John Young, Minister of the Interior, reported to King Kamehameha III that the first unit of Oahu's public water supply system was in operation. The installation consisted of a small reservoir, a leaden pipe to transport water to the harbor area, and a water tank located at the Harbor Master's office. Minister Young reported the cost at $2,647, but pointed out that the sale of water to sailing ships would probably bring the Monarchy a good profit.[3]

Three years later, Minister Young reported the completion of the second public water supply facility. This unit consisted of an iron pipe running from a reservoir at the King's Spring in Nuuanu to the harbor area. This installation was designed to serve whaling ships, but it also supplied water to many homes in the Valley and near the harbor. The new pipe spurred Honolulu's fire prevention efforts, and several cisterns were installed at key intersections in the growing town. By 1854, the population of Honolulu exceeded 11,000. The village was becoming a small city and it was clear that an expanded water supply system would soon be necessary. In the middle and late 1850's, William Webster, a civil engineer, designed and built a water supply system consisting of a new and larger reservoir, a 12 inch main and several distributing mains. Then this system was completed in 1861 and it was considered more than adequate for Honolulu's water supply needs.[4]

The discovery of artesian water at Honouliuli near Ewa in 1879 was a vital factor in the development of contemporary Oahu. Prior to 1879 most of the coastal district from

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[3] George F. Nellist, "An Early History of Honolulu's Water System," Honolulu: Honolulu Board of Water Supply, 1951, p. 1. (Mimeographed.)

[4] Ibid., p. 4.

Kaimuki to Kalihi and beyond in both directions was an arid plain, practically a desert. The town of Honolulu was dry and dusty, and the growing population of the late 1870's pressed against the limited water supply provided by shallow wells, springs and streams. There was little agriculture on Oahu except on the Windward side and in the valleys where streams provided an ample supply of water. Hawaiian Government Officials and the Editor of the Pacific C[illegible]ial Advertiser expressed concern that Oahu's economy [illegible]nolulu's growth would be sharply restricted by lack of available fresh water. The drilling of the first artesian well laid these fears to rest. In effect, artesian technology pushed back an environmental limit to growth by providing what seemed to be an inexhaustible supply of fresh water in 1879.[5]

James Campbell initiated the effort that resulted in the discovery and development of artesian water on Oahu. Campbell owned thousands of acres of land in Ewa and in the Central Oahu plateau. Practically all of the land was too dry to support agriculture; Campbell used it to pasture his cattle. Although successful artesian wells had been brought into production in Europe and on the mainland for over half a century, no one had attempted to locate artesian water in the Hawaiian Islands. Campbell engaged James Ashley, an experienced mainland well driller, to drill a deep well at Honouliuli. Work began in July, 1879, and after two weeks of drilling, at a depth of 240 feet, Campbell and Ashley struck artesian water. In October of that year, the Pacific Commercial Advertiser carried the following item:

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[5] George F. Nellist, "The Discovery and Development of Artesian Water," Honolulu: Honolulu Board of Water Supply, 1953, p. 1. (Mimeographed.)

> The Artesian Well--A recent visitor to Honouliuli reports the well as continuing to flow freely and without any diminution in the quantity of water discharged; constituting, in fact, quite a river which for the present and until planting can be accomplished, is allowed to run into the sea.[6]

Today a simple stone monument beside Fort Weaver Road commemorates the discovery of artesian water on Oahu. The monument is surrounded by acres of sugar cane, a bountiful contrast to the arid and barren plain that existed prior to Campbell's discovery.

Artesian water made the large scale cultivation of sugar cane feasible. In effect the sugar plantations, with their immense and continuing effects on the society and the economy of this Island community were made possible by the existence and discovery of vast quantities of artesian water. Oahu prospered. Her population increased, and Honolulu entered the Twentieth Century with the potential to become a flourishing mid-Pacific commercial center.

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[6] Ibid.

Within a year of the discovery at Honouliuli a second artesian well was brought into production on the property of Dr. Augustus Marques on Wilder Avenue near Punahou School. A contemporary observer heralded the new well, and artesian water in general, as holding "the promise of beauty and fertility for thousands of acres of almost useless land."[7] Many wells were drilled in the following years, and artesian technology transformed Honolulu from a dusty town into a city known worldwide for its arboreal and horticultural beauty.

Honolulu's first major reservoirs, one in Makiki and the other in Nuuanu Valley, were under construction at the same time that artesian water was discovered. These reservoirs were supplied by streams and springs; it was not until the Beretania Street pumping station went into operation in 1895 that artesian water contributed substantially to the municipal water supply.[8]

In 1881 a severe smallpox epidemic struck Honolulu. The Hawaiian Government and the community in general experienced a heightened interest in public health, and the safety of the water supply was called into question. One result was the construction of a filtering plant for the Nuuanu reservoir. A second effect was public insistence on conversion from the suspect surface streams and springs to unquestionably safe artesian sources.[9]

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[7] Ibid.

[8] Ibid., p. 3.

In the 30 year period following 1880, over 400 artesian wells were drilled on Oahu. Municipal wells were regulated, but they represented only a fraction of the total number of wells drilled. Most wells were uncapped. Water flowed freely for agricultural and domestic use, but immense quantities were wasted.

In 1913 the Territorial Legislature transferred the water system from Territorial control to the City and County of Honolulu. Two years later Mayor John C. Lane, acting with the agreement of the Board of Supervisors, appointed the Honolulu Water Commission to determine the status of Honolulu's water supply. After two years of investigation, the Commission described the situation as follows:

> The water supply system of the city has been created at haphazard, no comprehensive plan for its development having been formulated or adopted. As the population has grown and the demand for water increased, the system has been extended and added to, along the lines of least resistance. . . . This method of procedure has resulted in much unintelligent development and wasteful expenditure. . . . Again, the multiplication of pumping plants and wells drawing on the artesian system, has gone steadily on, notwithstanding the demonstrated fact that the system is already overtaxed; that the artesian water level is steadily falling, and that if radical remedial steps are not promptly taken, its complete failure, or at least extreme diminution, is due at an early date.[10]

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[9] Ibid., pp. 3, 4.

[10] Honolulu Water Commission, Report to the Honorable Mayor and the Board of Supervisors of the City and County of

The Commission listed the following reasons for this alarming situation:

1. Rapid population growth: 1854 ... 11,455
   1890 ... 22,907
   1915 ... 64,150
2. The mistaken belief that the artesian water supply is inexhaustible.
3. Frequent irrigation of Honolulu's abundant lawns and gardens.
4. The cleaning requirements of the newly constructed sewer system.[11]

The Honolulu Water Commission's report was a far-sighted and knowledgeable document. It articulated problems that were to confront water supply decision makers for the next half century. Here are the Commission's recommendations:

1. The immediate preparation of an Island-wide water plan to include agricultural as well as municipal use, and a detailed examination of all potential water sources in order to achieve their most rational development.
2. Decision makers should anticipate an annual population growth of 6% for the next twenty years.
3. All sources of water must be conserved.
4. Surface waters in Nuuanu are so polluted that they are a menace to public health; these waters should either be abandoned as a municipal source, or they should be rendered safe by adequate filtration.

Honolulu on the Available Water Supply for the City of Honolulu (Honolulu: Honolulu Water Commission, 1917), p. 4.

[11] Ibid., pp. 4, 5.

5. Leaky or abandoned artesian wells should be capped, and the drilling of new wells should be limited until the overdraft of the artesian supply is brought to an end.[12]

It took a prolonged drought beginning in the spring of 1923 and not ending until late 1926 before the community acted to protect its endangered water supply. The situation had deteriorated badly. In 1880, when the first artesian well was drilled in Honolulu, the artesian head stood at 42 feet above sea level. After forty years of unrestricted drilling the artesian head had declined to 26 feet. Engineers estimated that a decline to 18 feet would result in salt water intrusion and the destruction of the artesian water supply. If present trends were allowed to continue, the destruction of the municipal water system would occur in the early 1930's.[13]

In the 1970's, Oahu had begun to experience its water supply system as a limit to growth. Artesian technology had pushed back that limit and permitted forty years of expansion. But artesian technology had been abused. By the mid-1920's water supply was again perceived as a limiting factor in the growth and well-being of the Island community. This time a critical water shortage was averted through legislative action and institutional reform in addition to the application of new technology.

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[12] Ibid., pp. 6, 27, 28, 72, 89.

[13] Honolulu Sewer and Water Commission, Report of the Honolulu Sewer and Water Commission to the Legislature of the Territory of Hawaii, Fourteenth Regular Session (Honolulu: Honolulu Sewer and Water Commission, 1927), graph facing p. 12.

At the same time that the drought of the mid-1920's was having its effect on Oahu's water supply, corruption and inefficiency were uncovered in the City and County Waterworks Department. The Board of Supervisors commissioned an independent audit of the Department by the Henry Davis Audit Company. The audit revealed that over $120,000 of public funds had been embezzled or lost through mismanagement. The auditing firm's report indicated the extent of the problem:

> The needs of the department had far outgrown whatever system of accounting existed. . . . Office methods were so amaturish and incomplete that opportunity for losses, if not defalcations, existed at every turn. The department had no knowledge of what its revenue should be, or of the amount of charges sent out. . . .
>
> The staff organization was crude. . . . Office discipline and co-ordinating, comparatively speaking, did not exist. . . . The forms and books were unsuitable, improperly kept and misused; numerous records were lost or stolen. . . .
>
> Existing detail maps were quite useless. . . . It can be said that no system of mapping privileges or of recording the location of mains, laterals, manholes, fire hydrants, etc. existed.[14]

Three former Waterworks Department employees were convicted of stealing public monies and were given long prison terms. The City administration took action: Mayor John Wilson appointed former Territorial Governor, Charles J. McCarthy, a man of unimpeachable integrity, to be Supervisor of the Waterworks Department; and the Henry Davis

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[14] Honolulu Advertiser, June 10, 1925, pp. 1, 2.

Audit Company instituted an efficient office system to replace the administrative and fiscal disorder that had existed in the Department.[15]

The Territorial Legislature took action by passing Act 150 of the regular session, 1925, which established the Honolulu Sewer and Water Commission for a period of five years, and charged it with providing "a permanent and adequate supply" of fresh water for the City of Honolulu.[16] The Commission held its first meeting on May 14, 1925, and two weeks later it appointed for its Chief Engineer a man who was to have a considerable impact on Oahu's water supply system in the Twentieth Century: Frederick Ohrt. Within a few weeks Ohrt had virtually completed the organization of the staff of the Honolulu Sewer and Water Commission (HS&WC).[17]

In January, 1927, Frederick Ohrt submitted his first major report to the members of the HS&WC. His assistants, G. K. Larrison and John McCombs, described the situation in these terms:

> The city is supplied with water through antiquated equipment which is by no means a system, but an unplanned patchwork of unrelated units. There are frequent water shortages in many parts of the city, there is an ever present fire menace, growth

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[15] Ibid., March 4, 1925, p. 1, and June 10, 1925, p. 4.

[16] Report of the Honolulu Sewer and Water Commission to the Legislature of the Territory of Hawaii, 1927, p. 4.

[17] Ibid., p. 3.

> is hampered, and, in general the water system has lagged far behind the needs of the City.[18]

Ohrt called for a forced conservation program in order to achieve a dramatic reduction in the daily draft from the artesian supply:

1. Complete government ownership and control of all artesian waters in the District of Honolulu.
2. Prohibiting the drilling of new wells except for government use, and the sealing of all other wells.
3. The metering of all water privileges, and complete accounting for all water pumped into the system.
4. An increase in the water rate in order to provide an incentive for individual conservation.[19]

Complete government ownership of Honolulu's artesian wells was too radical a proposal to be accepted by the Territorial Legislature. But in 1927 the Legislature did provide regulatory powers for the HS&WC including the authority to grant or refuse permits for the drilling of new wells within the District of Honolulu. The law providing these powers, Act 222 S.L. 1927, was challenged by the City Mill Company, Ltd., when the HS&WC refused to grant the Company a permit to drill a new artesian well. The case went to the Territorial Supreme Court which decided that, based on the legal doctrine of "correlative rights," a land owner is entitled to a share of any ground water that may exist under his property. The Supreme Court's ruling did not interfere with the Commission's right to regulate drilling; the Court merely determined that the Commission had no right to prevent it entirely. In any case, the heyday of artesian well drilling was over. Only one new well was drilled in the two year period beginning in 1929, and it was drilled in accordance with regulations.[20]

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[18] Ibid., p. 9.

[19] Ibid., pp. 16, 17.

In 1931 water rates increased to .12 per 1,000 gallons of water for domestic use. Rates went up to .18 per 1,000 gallons in 1933. But the metering of the City was a more fundamental factor in the success of the conservation program than the raising of rates. Ohrt's conservation program was a clear success. Consumption fell from 233 gallons per person per day in 1924, to 131 gallons in 1934.[21]

The accomplishments of HS&WC under Frederick Ohrt's supervision were remarkable. In addition to the conservation program described above, the HS&WC carried out a number of vital construction projects. Between 1926 and

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[20] Honolulu Board of Water Supply, Report of the Board of Water Supply, City and County of Honolulu, to the Legislature of the Territory of Hawaii, Sixteenth Regular Session (Honolulu: Honolulu Board of Water Supply, 1931), p. 17.

[21] Honolulu Board of Water Supply, Report of the Honolulu Board of Water Supply, City and County of Honolulu, to the Legislature of the Territory of Hawaii, Eighteenth Regular Session (Honolulu: Honolulu Board of Water Supply, 1935), p. 16.

1928 the three main pumping facilities, at Beretania St., in Kaimuki and in Kalihi were substantially reconstructed. New fireproof buildings were added and modern steam pumping equipment was installed. New artesian wells were drilled at these key locations, and the three stations were joined together by large mains so that any two stations could meet the water demands of the entire system.[22] One important financial effect of these efforts was a 25% reduction in fire insurance rates for the City of Honolulu.[23]

The Commission intensified efforts to locate and seal lost and defective artesian wells. Sixteen wells were sealed in 1928 and 1929, and HS&WC inspection teams earmarked many other wells for repair. Crewmen investigated and repaired leaky reservoirs and water pipes as part of the Commission's construction-conservation program. The HS&WC instituted the water resources research program suggested by the Honolulu Water Commission in 1917 by authorizing J. F. Kunesh of the U.S. Geological Survey to carry out detailed studies of Oahu's surface waters.[24]

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[22] Honolulu Sewer and Water Commission, Report of the Honolulu Sewer and Water Commission to the Legislature of the Territory of Hawaii, Fifteenth Regular Session (Honolulu: Honolulu Sewer and Water Commission, 1929), p. 45.

[23] George F. Nellist, "Building a Modern Water System," Honolulu: Honolulu Board of Water Supply, 1955, p. 1. (Mimeographed.)

[24] Honolulu Sewer and Water Commission, Report to the Legislature, 1929, pp. 15, 16, 71.

In 1933, the Honolulu Board of Water Supply, successor to the HS&WC, reported a marked reduction in demand on the artesian water supply and attributed this success to five factors:

1. The metering of all services.
2. Monthly billing.
3. The sealing of leaky wells.
4. The reduction of distribution and storage system losses and the metering of private wells.
5. A material reduction in unaccounted for water, from 39% of the water entering the system in 1928 to 19% in 1932.[25]

Two factors beyond the control of water supply decision makers contributed to the success of the conservation program: rainfall was above average for the six year period beginning in 1927;[26] and the Great Depression took its toll of Oahu's economic activity and population growth. Prior to the Depression, Honolulu's population had been growing at the rate of about 6,000 per year. But because of the downturn in economic activity the population increased only 2,600 per year in 1931 and 1932. Population showed a decrease of 3,000 in 1933, and remained stable at about 141,000 in 1934.[27]

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[25] Honolulu Board of Water Supply, Report to the Legislature, 1933, pp. 3, 4.

[26] Honolulu Board of Water Supply, Ninth Biennial Report of the Board of Water Supply, City and County of Honolulu (Honolulu: Honolulu Board of Water Supply, 1943), graph facing p. 10.

Regardless of natural factors and worldwide economic conditions, water supply decision makers achieved dramatic results in the years following 1925. They averted a catastrophic water shortage and established the foundation of Oahu's modern water supply system. One of the clearest measurements of their success is that the artesian head, which had dropped from 42 feet in 1880 to 23.5 feet in 1926, rose to 32 feet by the end of 1932.[28] Frederick Ohrt expressed satisfaction with the results accomplished in what had been a near critical water supply situation:

> That problem I now feel, for the first time, has been solved, as far as any problem can be called solved in the life history of a growing waterworks of a modern city. . . .[29]

In 1929 the question of the institutional structure of the water supply system came to the fore. The Legislature had established the HS&WC in 1925 for a term of five years. The City Waterworks Department had undergone reform since the abysmal days of 1925, and was serving as the effective working arm of the HS&WC. The Department had installed the thousands of water meters that contributed to conservation and helped produce enough revenue to make the water supply system financially self-sufficient. In addition, the Department was compiling detailed maps showing the location of all mains, services and meters, and was installing a modern recording and accounting system. Moreover, the Department operated the system's three new pumping stations and all of its other water supply facilities. Although the Waterworks Department was accused of inefficiency from time to time, the weight of evidence suggests that the Department made a significant contribution to the conservation and modernization effort.[30]

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[27] Honolulu Board of Water Supply, Report to the Legislature, 1933, p. 15, and Report to the Legislature, 1935, pp. 5, 6.

[28] Honolulu Board of Water Supply, Report to the Legislature, 1933, p. 4.

[29] Ibid., p. 92.

Late in 1928, the Hawaii Bureau of Governmental Resources brought Carl E. Grunsky, a well-known consulting engineer, to Oahu to study the water situation. In January, 1929, Grunsky made a verbal presentation of his findings to government officials, members of the HS&WC and other leading citizens assembled in the Chamber of Commerce board room. He said, in effect, that the critical water supply situation was stabilizing, that the HS&WC had been doing an excellent job, but that a great deal of work remained to be done. He advised the spending of $3,000,000 on a three to four year construction program (precisely the sum the HS&WC had requested in 1927), and the raising of water rates to .20 per 1,000 gallons for domestic users. Most important from the institutional standpoint, Grunsky recommended the creation of an agency of control over the City's water supply system that would not be subject to a change in personnel with every change of the City administration.[31]

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[30] Honolulu Sewer and Water Commission, Report to the Legislature, 1929, p. 41.

Grunsky was calling for the establishment of an autonomous, or semi-autonomous, water supply agency for Honolulu. The establishment of quasi-independent public agencies was one of the measures advocated by "good government" reformers during the Progressive Era (from about 1900 into the 1920's). The purpose of these agencies was to take power out of the hands of bosses and corrupt political machines, and grant power to professional, civil-service bureaucracies. Reformers felt that the political processes were vulnerable to corruption, and advised the establishment of semi-autonomous agencies to separate whole areas of public service responsibility and authority from the political processes. These agencies provide increased professionalism and continuity of personnel, but they operate at some distance from the electorate and the checks and balances of the political system.

As far as the institutional future of Honolulu's water supply system was concerned, efficiency and continuity may have been legitimate reasons for establishing a semi-autonomous water supply agency. But bossism and corrupt machine politics were not legitimate issues. Political power resided primarily in the Office of the Governor and the Territorial Legislature, not in Mayor John Wilson's City administration.

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[31] Honolulu Star-Bulletin, January 4, 1929, pp. 1, 10; Honolulu Star-Bulletin, February 1, 1929, pp. 1, 2.

Grunsky's recommendation was consistent with the following recommendation made by Frederick Ohrt a year earlier:

> (The Territorial Legislature should) authorize by the consolidation of any and all phases of the water problem, including investigations and development, construction, supply, distribution, equipment and finances, under one body with full authority and fixed responsibility of solving the Honolulu water problem.[32]

Ohrt was recommending, in effect, that the term of the HS&WC be allowed to expire in 1930, and that the City Waterworks Department be abolished in favor of a single agency possessing the responsibility and authority of both the HS&WC and the Waterworks Department. The Cooke Bill, which embodied Ohrt's suggestions and proposed the creation of a semi-autonomous Board of Water Supply, came up for consideration by the Territorial Legislature early in 1929.

The day after Carl Grunsky made his recommendations at the Chamber of Commerce, Riley Allen of the Honolulu Star-Bulletin editorialized in favor of creating a semi-autonomous water supply agency:

> At a time when the victors in the recent elections are busy dividing up the spoils of political war . . . (Grunsky's) recommendations come with

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[32] Honolulu Sewer and Water Commission, Report to the Legislature, 1927, p. 6.

> singular force. Ultimately we hope that Honolulu will place its water and sewer system--city functions absolutely vital to health--beyond the reach of the political job distributors.[33]

Influential people in the community, legislators, editors and key staff members of the HS&WC favored the establishment of the Board of Water Supply on the grounds of administrative continuity, operational efficiency and freedom from political control. But the Board of Supervisors went on record against the formation of a semi-autonomous water supply agency. Supervisor Manuel Pacheco inveighed against the Cooke Bill before his colleagues:

> It has been said by the proponents of this bill that it will take the waterworks out of politics and place it under an efficient management. I say that if they are sincere about the politics, then place the waterworks under civil service control, but keep it under the management of the City and County where it belongs. I am in favor of civil service for this department and above all I am opposed to having the Territory take it away from us.[34]

The Board of Supervisors passed a resolution asking the Territorial Legislature to vote against the Cooke Bill on the grounds that the Cooke Bill is equivalent to confiscation of City and County property by the Legislature; that the City has as much right to operate a Waterworks Department as it has to provide other essential public services; and in any case, the City Waterworks Department has earned surplus revenue for several years and has provided adequate service at reasonably low rates.[35]

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[33] Honolulu Star-Bulletin, January 4, 1929, p. 6.

[34] Honolulu Advertiser, March 6, 1929, p. 1.

A second public discussion of the Cooke Bill took place in mid-March, 1929. The occasion was a joint session of the Board of Supervisors and the Senate Select Committee headed by Senator Cooke. Mayor Wilson and Frederick Ohrt of the HS&WC were present. The Mayor denounced the Bill on the grounds that the City's water supply facilities are the property of the people of Honolulu and the people should not be denied control of their property by the establishment of a commission responsible to no one. The Mayor strongly suggested that the interests of fiscal responsibility and efficiency would be best served by placing the operation of the water supply system entirely under the direction of the elected representatives of the people, that is, the Board of Supervisors.[36]

There were two important factors involved in the passage of the Cooke Bill. One factor was political, and the other was primarily economic. On the political side, Mayor Johnny Wilson, as a Democrat and a populist, offended the dominant Republican party with his independence and his grass roots style. The Cooke Bill gave the Republican majority in the Territorial Legislature the opportunity to slap Mayor Wilson's wrists. From the economic perspective, agriculture was the mainstay of the Island's economy. An ample supply of fresh water was absolutely vital to Oahu's sugar and pineapple interests. The Territorial Legislature was sensitive to these agricultural interests, and the Legislature wanted to prevent, or at least delay, the time when the City of Honolulu would look beyond its own boundaries for water for its growing population. It is reasonable to assume that many legislators voted for the Cooke Bill because they saw the creation of a semi-autonomous water supply agency as a means of protecting plantation agriculture's vital interest in Oahu's water.

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[35] Ibid., p. 2.

[36] Honolulu Advertiser, March 15, 1929, pp. 1, 2.

By the end of March, 1929, the Mayor had accepted the passage of the Cooke Bill as inevitable and was lobbying among the legislators for amendments which would give the City Administration a voice in the management of the new agency.[37] A good deal of discussion centered on the degree of autonomy to be granted to the Board of Water Supply. Territorial Governor, Wallace R. Farrington, held the opinion that the City and County should have a significant role in the appointment of the members of the Board. He expressed distrust of a wholly independent BWS on the grounds that "all these boards and commissions have a tendency to set up little governments of their own."[38]

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[37] Honolulu Advertiser, March 30, 1929, p. 1.

[38] Ibid.

In its final form Act 96 embodied a significant concession to Mayor Wilson and the Board of Supervisors by providing for strong representation for the City and County on the Board of Water Supply. Act 96 provided that two members of the seven member Board would serve in an ex-officio capacity, the Superintendent of Public Works of the Territory, and the Chief Engineer of the Department of Public Works of the City and County. The Governor appointed the other five members of the Board for terms of one, two, three, four and five years. As these terms expired, the Mayor, with the approval of the Board of Supervisors, would then have the right to appoint new members to serve staggered five year terms. The members of the Board were to serve without compensation.

The Legislature assigned major responsibilities to the Board of Water Supply:

> To manage, control and operate the water system and properties of the City and County of Honolulu, for the supplying of water to the public within the District of Honolulu; and to collect, receive, expend and account for all sums of money derived from the operation thereof. . . .[39]

Act 96 also granted the Board the power to sell bonds and determine water rates so that "the revenues derived therefrom shall be sufficient to make the water works self-supporting. . . ."[40] Furthermore, Act 96 provided that the Board could purchase, lease or otherwise acquire "all property situated within the limits of the City and County that it may determine necessary for the construction, maintenance, extension or operation of the works under its jurisdiction and control."[41] As for management, the Board was authorized to appoint a Manager "who shall have full power to administer the affairs of the water works, subject to the direction and approval of said Board."[42]

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[39] Hawaii, Session Laws, 1929, Act 96.

[40] Ibid.

A careful reading of Act 96 indicates three limitations on the independence of the Board of Water Supply. One limitation is the appointive power of the Mayor. A second is that the Board has no independent legal branch; it must depend upon the legal staff of the City and County for legal advice and action. Third, although the Board has broad discretionary powers in financial matters, its accounts are subject to inspection by the City and County Auditor. Nevertheless, the Honolulu Board of Water Supply is one of the most independent of the semi-autonomous water supply agencies serving major metropolitan areas in the United States. A comparative study of fifty-five municipal water supply agencies conducted by Council Services, City and County of Honolulu, indicates that of the eight semi-autonomous water supply agencies responding, only the agency serving Des Moines, Iowa, enjoys a degree of autonomy equivalent to that granted to the Honolulu Board of Water Supply by Act 96, S.L. 1929.[43]

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[41] Ibid.

[42] Ibid.

Governor Farrington's signing of Act 96 on April 29, 1929, and his appointment of the first Board of Water Supply on July 1, 1929, brought an end to a momentous era in the history of Oahu's water supply. The conservation and modernization measures begun in 1925 were bearing fruit. The environmental limit to Oahu's growth caused by the dwindling artesian water supply had been extended. The underground supply of fresh water was increasing for the first time in recorded history. In addition, public policy decision makers were reasonably confident that the reforms contributing to this progress had been institutionalized, made permanent, by the creation of the semi-autonomous Board of Water Supply.

In a fitting close to the tumultuous decade of the 1920's, Mayor Wilson refused to hand over control of the City's water supply facilities to the Board of Water Supply on the grounds that Act 96 was unconstitutional. The Board of Supervisors and the Board of Water Supply agreed to submit their differences of opinion and policy to the Territorial Supreme Court.[44] On January 27, 1930, the Supreme Court ordered the Mayor and the Board of Supervisors to stop interfering with the Board of Water Supply in the exercise of its powers and duties under Act 96. The Board of Water Supply assumed control four days later, and on the same day, February 1, 1930, appointed Frederick Ohrt, Manager and Chief Engineer.[45]

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[43] Interview with Lily Okamoto held in Council Services Office, City and County of Honolulu, September, 1974.

[44] *Honolulu Advertiser*, June 25, 1929, p. 4.

The engineers of the HS&WC, who had become the engineers of the Board of Water Supply, had always been primarily interested in the water supply conservation and construction program. They expended considerably less energy on the City's sewer system. During the HS&WC years, 1925-1930, there were significant improvements in Honolulu's waste water disposal facilities. Yet the water supply situation remained the consuming interest of Fred Ohrt and his staff. In January, 1932, all of the plans and records of the sewer system were turned over to the Department of Public Works, City and County of Honolulu. And the sewer system remained separate from the water supply system for over forty years.[46]

The Great Depression provided the Board of Water Supply with unexpected respite from increasing demands upon the water supply. But the decline in economic activity that reduced the demand for water also left the Board with a marked decline in receipts from the sale of its product.

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[45] Honolulu Board of Water Supply, Report to the Legislature, 1931, pp. 11, 12.

[46] George F. Nellist, "Building a Modern Water Supply System," p. 3.

This situation caused the Board to set higher water rates beginning in 1933.[47]

The year, 1933, was an extremely dry year. The experience of that year underlined the fact that rainfall is still the basic factor in water supply. The artesian head dropped three feet in the two year period beginning in 1933 in spite of all of the conservation measures that had already been put into effect. In 1935 Fred Ohrt reported an intensified effort to educate the community about conservation. Board of Water Supply employees emphasized conservation in community discussions and classroom lectures. The Board included conservation reminder slips in its monthly billing, and leakage notices were sent out as soon as leakage or waste was suspected. Fred Ohrt saw a close relationship between conservation and good public relations:

> It is our continuing endeavor to maintain friendly relations that will make the water user conscious of the fact that he is a partner in the water works and has an active interest in its welfare. That these public relations activities are beneficial has been manifested in many ways, particularly in awakening more interest in conservation.[48]

The depression and the New Deal brought substantial federal aid to the Board of Water Supply. By 1939, the Public Works Administration had granted the Board a total of approximately $842,000. In order to qualify for the grants, the Board of Water Supply sold $450,000 worth of revenue bonds. The Federal Emergency Relief Administration and the Works Progress Administration contributed labor. Reservoirs and pumping stations were built, scores of miles of water mains were installed, and hundreds of men were put to work on projects that contributed significantly to the modernization and expansion of Honolulu's water supply system.[49]

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[47] Honolulu Board of Water Supply, Report to the Legislature, 1933, p. 87.

[48] Honolulu Board of Water Supply, Seventh Biennial Report, Board of Water Supply, City and County of Honolulu, 1939, p. 19.

Frederick Ohrt's January 15, 1941, report to the Members of the Board of Water Supply is a significant document because Ohrt perceived that the depression era had come to an end and that the 1940's presented unprecedented challenges to the Board of Water Supply. Ohrt pointed with pride to the results achieved by the ongoing conservation and modernization program. But he expressed concern over the rapid increase in population and demand on the water supply system caused by the reinforcement of Oahu's defenses. The following observation is particularly insightful in view of the fact that Ohrt made it eleven months before the attack on Pearl Harbor:

> The enormous expansion of the military and naval establishments here is largely of a permanent nature, and the number of civilian employees required for their maintenance and operation is certain to be much greater than heretofore.[50]

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[49] Ibid., p. 21.

[50] Honolulu Board of Water Supply, Eighth Biennial Report of the Board of Water Supply, City and County of Honolulu, 1941, p. 8.

In this same report Ohrt emphasized that the construction program of 1939 and 1940 had made a substantial increase in the available water supply:

> Centralization of our operations in the new Board of Water Supply Building, and other progressive steps initiated by this Board when it adopted its biennial program two years ago, made it possible to enter upon the transition from normal operations to an emergency basis with comparative ease.[51]

Ohrt pointed to the experience of other nations in the war years of 1939 and 1940 and expressed concern that Honolulu's water supply might become the target of sabotage. "Conserve Water" had been the watchword of the HS&WC and the Board of Water Supply. In 1941 the Board added a new watchword: "Defend Honolulu's Water Supply."[52]

At the end of the 1930's and the beginning of the 1940's a new application of technology bore fruit for the Board of Water Supply. The technique involves the drilling of a shaft on an incline into the earth to the level of the fresh water lens. A horizontal tunnel is then excavated through the water bearing lava. Fresh water quickly fills the tunnel which becomes, in effect, a horizontal well. Pumps are then placed in a chamber just above the level of the lens, and the fresh water is pumped to the surface. The inclined shaft underground station, known as the "Maui type" well had been proven successful on Maui, Hawaii and Kauai by sugar plantations in search of ample supplies of high quality water. The first two inclined shafts in Honolulu were located in Kalihi and Waialae and were brought into production in 1937. Four years later Fred Ohrt expressed satisfaction with these two shafts, and suggested the inclined shafts could eventually replace artesian wells as a method of obtaining pure water.[53]

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[51] Ibid.

[52] Ibid., pp. 9, 10.

When the Territorial Legislature created the HS&WC in 1925, it placed the Commission under a major constraint:

> (The HS&WC must) insure the City of Honolulu a permanent and adequate supply without immediately going outside the District of Honolulu and thereby depriving the agricultural and industrial enterprises of water necessary for irrigation and manufacture.[54]

The HS&WC and the Board of Water Supply had operated under that constraint throughout the difficult period of the late 1920's and early 1930's. In 1941, Fred Ohrt began to prepare Oahu's agricultural interests, and the Territorial Legislature, for the time when the Board of Water Supply would go beyond the District of Honolulu (from Makapuu Point to Red Hill) to obtain a portion of the City's water supply. The Board, he said, would provide for Honolulu's needs without going outside the District "until such time as all available water sources within the District of Honolulu have been developed to their utmost extent." And:

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[53] George F. Nellist, "Building A Modern Water System," p. 4.

[54] Hawaii, Session Laws, 1925, Act 150.

> Increased population and its sudden new demand on water service necessitate adjustments and expansion of plant and service facilities and preparations for their protection that are far beyond normal expectations.[55]

In April, 1942, the Board began work on the North Halawa Valley underground pumping station. Thus the Board was compelled by the increased demand brought on by World War II to go outside the limits of the District of Honolulu to augment the City's water supply. A 284 foot shaft inclined at 30° was excavated in North Halawa Valley. At the base of the shaft, engineers built a pumping chamber and a horizontal tunnel extending 900 feet through the water bearing lava to collect millions of gallons of fresh water from the lens just above sea level. Two electrically operated pumps were installed in the chamber just above the level of the lens to pump the water to the surface. The rated capacity of each pump was five million gallons of water per day, and engineers provided for eventual expansion to 20 million gallons per day. Four miles of 42 inch and 36 inch pipe carried Halawa water into the City of Honolulu. Eventually the "Big Inch" main extended to central Honolulu, nine miles from North Halawa. By 1943, the estimated cost of the project was $1,500,000 (construction costs eventually exceeded $2.1 million). The Federal Works Agency contributed $683,250, and the Board of Water Supply sold two revenue bond issues to finance the City's share of the cost.

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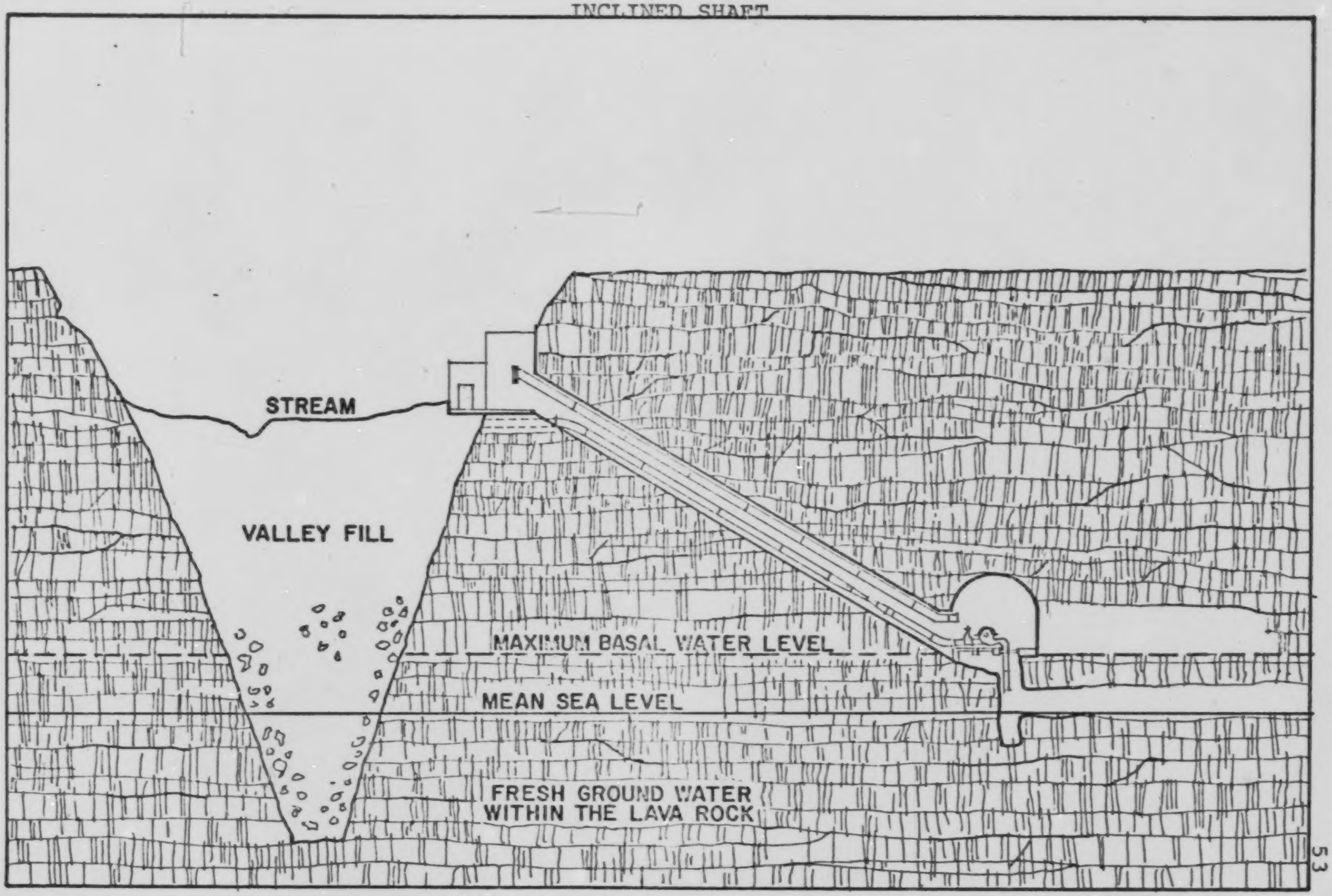
[55] Honolulu Board of Water Supply, Eighth Biennial Report, 1941, p. 10.

ILLUSTRATION 1

INCLINED SHAFT


STREAM
VALLEY FILL
MAXIMUM BASAL WATER LEVEL
MEAN SEA LEVEL
FRESH GROUND WATER
WITHIN THE LAVA ROCK

The Halawa Valley station went into operation in August, 1944. It remains the most important single project ever undertaken by the Board of Water Supply.[56]

As soon as the bombs stopped falling on Sunday, December 7, 1941, Board of Water Supply work crews reported for emergency duty. They had two broken mains and two service breaks to cope with as a result of bomb and anti-aircraft shell damage. Regular Army units had been assigned to guard major Board of Water Supply installations prior to the attack on Pearl Harbor. That protection continued throughout the War, and Board of Water Supply personnel were armed and trained to take over guard duties in case the Army units were needed to repel an invasion of the Islands. The Board of Water Supply remained on semi-alert throughout the War.[57]

Artesian head, the primary measurement of the subterranean water supply, showed a definite decline during the war years. The artesian head dropped from 29.38 feet in 1939, to 22.07 feet in 1946. The period from 1940 to 1946 inclusive, was the driest seven year period on record. In only one of those years did the rainfall exceed the annual average. A second factor was the rapid increase in population. The 1940 census showed 179,400 people, excluding military personnel, living in the District of Honolulu. By 1946, the resident population had increased to 268,000. During the war years it was virtually impossible to estimate the number of people using water in Honolulu because of the tens of thousands of military personnel in garrison and in transit on Oahu. Defense construction and other military activities contributed to the demand on the subterranean water supply.

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[56] Honolulu Board of Water Supply, Ninth Biennial Report of the Board of Water Supply, City and County of Honolulu, 1943, p. 4; George F. Nellist, "Building A Modern Water System," pp. 4, 5.

[57] Board of Water Supply, Nintn Biennial Report, pp. 5, 6, 28.

The situation grew particularly serious in the Moanalua artesian head because the U.S. Navy had constructed a pumping station at Red Hill, over Board of Water Supply objections, and was pumping over 20 million gallons per day of Moanalua water for transmission to Pearl Harbor. The heavy withdrawal, plus drought conditions, was responsible for a rapid decline in the artesian head in the Moanalua area. Two wells increased from about 100 parts per million of chloride in 1940 to over 250 parts per million of chloride in 1946. The U.S. Public Health Service standard of potability for domestic water supplies is 250 parts per million of chloride. Although salinity declined in some wells when the overdraft of the war years had ended, Fred Ohrt cautioned against undue optimism:

> We have no indication that there is any reversal of the long-term trend and we see no escape from the prospect that shrinkage of the fresh water supply below sea level will continue despite occasional increases in the artesian head above sea level. This condition points to the necessity for eventual retreat from the deeper parts of the aquifer and is

> the fundamental reason for the projected underground pumping stations which in time will replace the existing deep-well stations.[58]

Early in 1945 Fred Ohrt announced that the Board had approved the construction of recharging tunnels as a means of augmenting the artesian water supply. Recharging tunnels had been planned since before the War, but had been delayed in favor of the Halawa Valley project on the grounds that the Halawa project would have a more immediate beneficial effect on Honolulu's wartime water supply situation.

In 1945, recharging tunnels were contemplated for Nuuanu, Manoa and Palolo Valleys. Engineers planned to build small dams to divert water from the streams in the Valleys into tunnels drilled into the Koolau Mountains. Water would then percolate through the lavas and increase the artesian water supply. Engineers calculated that diversion and recharge from the three streams could provide about ten million gallons of water per day to the underground supply. But the recharging tunnels were never built. Although detailed plans of the Nuuanu recharging tunnel were prepared, the project was relegated to "pilot" status in the Biennial Report of 1955-56. According to Mr. Kawakami of the Board of Water Supply, Engineering Division, the plans to build recharging tunnels were finally abandoned for lack of funds. Mr. Kawakami cited high drilling costs as a reason why the Board would probably not build recharging tunnels in the foreseeable future.[59]

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[58] Honolulu Board of Water Supply, Eleventh Biennial Report of the Board of Water Supply, City and County of Honolulu, 1947, pp. 9, 14, 24, 25; Twelfth Biennial Report, 1949, pp. 3, 8.

It makes sense to use a certain amount of stream water to recharge the artesian basin rather than letting such waters run off to the ocean. The writer believes that the construction of recharging tunnels should be reconsidered in view of the increasing demand for water and the relative costs and benefits of other water supply alternatives.

In 1944, Wells A. Hutchins, the author of The Hawaiian System of Water Rights, made a detailed study of Oahu's water supply situation, and prepared a ground water statute for introduction to the Territorial Legislature. The Board of Water Supply and Manager Fred Ohrt joined Hutchins in calling for the passage of the statute and the creation of an Oahu Ground Water Commission. The key points of the proposed ground water statute were:

> 1. Subject to existing rights of use as validated under provisions of this statute all ground waters within the Island of Oahu are declared to be public waters and to be the property of the public.
>
> 2. Creation of a commission, appointed by the Governor, to study ground water supply, control withdrawals of ground water and possible uses of ground water and review claims of rights of use of such water.

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[59] Honolulu Board of Water Supply, Tenth Biennial Report of the Board of Water Supply, City and County of Honolulu, 1945, p. 12; Honolulu Board of Water Supply, Sixteenth Biennial Report, Board of Water Supply, 1957, p. 41; telephone conversation with Mr. Kawakami, Honolulu Board of Water Supply, Engineering Division, Honolulu, Hawaii, October 23, 1974.

3. Authorizes the commission to maintain an office and to employ such persons as may be necessary.

4. Grants the commission the power to intervene on behalf of the public in any suit at law or in equity in any court in which the control or withdrawal of any ground waters in the Island of Oahu or rights to their use is an issue; and to institute proceedings for the determination of ground water rights.[60]

Ohrt realized that the proposed legislation would eliminate certain statutory powers of the Board of Water Supply relating to the investigation of water use and the regulation of well drilling within the District of Honolulu. Future ground water development by the Board would be subject to the approval of the proposed commission. Nonetheless, Ohrt supported the proposed legislation because its purpose was to initiate Island-wide regulation and control of water resources.[61]

Ohrt saw all of Oahu's water resources as essentially a single resource. He recognized the diverse interests of the Island's many water users: the Board of Water Supply, the Suburban Water System, several dozen privately owned systems, and the systems in use on several military bases. He was convinced that an Island-wide regulatory body was essential to the beneficial development and use of Oahu's water resources.

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[60] Honolulu Board of Water Supply, Tenth Biennial Report, 1945, pp. 3, 6.

[61] Ibid., p. 7.

The proposed statute was brought before the 1945 session of the Territorial Legislature, but was assigned to the Holdover Committee for further study. It was re-introduced in the 1947 session, and again in 1949, but met the same fate. Opposition to the bill centered on the provision declaring all ground waters to be public property. Land owners, especially plantation interests, objected on the grounds that this provision would unjustly deprive them of a property right, the right to own the ground waters underneath their land.

In May, 1952, Edward J. Morgan succeeded Frederick Ohrt as Manager and Chief Engineer of the Board of Water Supply. In his report to the Board early the following year, Mr. Morgan did not recommend the re-introduction of the proposed ground water statute. Instead he offered the Legislature some general advice about "safeguarding, conserving and protecting" Oahu's water resources.[62]

Although Fred Ohrt's retirement from office marked the end of the Board's active support for a detailed, tightly written, ground water statute for Oahu, the Legislature took a cautious step in the direction he advocated by creating the Hawaii Irrigation Authority (HIA) in 1953. The five commissioners of the HIA were granted significant powers in the relatively limited area of irrigation. During its four year existence, the HIA carried out feasibility studies of irrigation projects intended to meet the water supply needs of small agricultural enterprises. The HIA was empowered to issue revenue bonds to fund the establishment and operation of irrigation projects, and to manage irrigation projects for the benefit of small-scale agriculture and the over-all economy of the Territory. Interestingly enough, the Legislature explicitly denied the HIA the right to establish an irrigation project on Oahu (with the exception of a project in Waimanalo), without first consulting with the Honolulu Board of Water Supply and the Suburban Water System of the City and County of Honolulu.[63]

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[62] Honolulu Board of Water Supply, Eleventh Biennial Report, 1947, p. 8; Twelfth Biennial Report, 1949, p. 8; Thirteenth Biennial Report, 1951, p. 11; Fourteenth Biennial Report, 1953, p. 51.

In 1957, the Legislature re-named the Hawaii Irrigation Authority, the Hawaii Water Authority (HWA), and granted the HWA additional powers. The HWA was ordered to conduct surveys of Territorial Water Resources so that "a master plan for the development, conservation and most beneficial use of all such water resources" could be formulated. The Legislature further requested the HWA to study information on evaporation, distillation and other processes for raising the quality of non-potable water and making it fit for domestic use. In addition, the HWA was advised to study methods of converting "brackish, salt or other water" for agricultural and industrial use. The Legislature added the provision that "nothing in this act shall be deemed to restrict or modify the powers and duties of the several Boards of Water Supply and Water Departments."[64]

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[63] Hawaii, Regular Session, 1953, Act 245.

During the next four years the HWA conducted a detailed inventory of Territorial water resources as a step toward formulating a comprehensive water program and integrating it with the Territorial Planning Office's program for the economic development of the Islands.[65]

In 1959, the Territorial Legislature passed Act 274, the Ground Water Use Act. The Act, with one significant change, remains the ground water law of the State of Hawaii. In Act 274 the Legislature declared the following water resource policy:

> 1. The development, utilization and control of all ground-water resources shall be directed to make the maximum contribution to the public benefit.
>
> 2. The ground-water resources of all areas must be regulated and protected from the threat of exhaustion, depletion, waste, pollution or deterioration by salt encroachment to assure adequate supplies for beneficial uses.
>
> 3. The Territory . . . acting through the commission on water resources should control the development and use of the ground-water resources of the Territory in all areas and in

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[64] Hawaii, Regular Session, 1957, Act 22.

[65] Hawaii Water Authority, Water Resources in Hawaii, p. iii.

> areas where the supply is threatened with exhaustion, etc. . . .[66]

By Act 274, the Legislature created a commission on water resources as indicated in the policy statement above. But the commission was short lived. In August 1959, Hawaii became the Fiftieth State of the Union. With Statehood came a new Constitution. Article IV, Section 6, of the new Constitution provided that the number of executive and administrative offices must be limited. Prior to Statehood, the number of such offices, departments and commissions had grown to over one hundred. In the reorganization that followed Statehood, the commission on water resources and the Hawaii Water Authority were abolished and their powers and duties were granted to the newly created Department of Land and Natural Resources (DLNR). The establishment of the DLNR under the Board of Land and Natural Resources constitutes the only significant change in Hawaii's ground water law from 1959 to the present.[67]

The Legislature granted significant regulatory powers to the commission on water resources and its successor, the Board of Land and Natural Resources. The Board has the power to conduct studies, consult with advisory boards and water user associations and to promote agreements among ground water users.

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[66] Hawaii, Revised Statutes, Sec. 26-15.

[67] Hawaii, Revised Statutes, Sec. 26-15.

The Board may designate a ground water area for control if it finds any of the following:

1. Ground water use exceeds recharge.
2. Ground water levels are declining excessively.
3. Saline content is increasing significantly.
4. Excessive waste is occurring.
5. Proposed water development would probably lead to one of these conditions.

If the Board designates an area for protection, several water use controls including a permit system go into effect. The Board has special powers for regulating and apportioning water resources in the event of a water shortage in a designated ground water control area. And it has emergency powers which have been described as "martial law" for water:

> 1. (The Board may) establish rules, regulations or orders limiting, apportioning, rotating, or prohibiting the use of the water resources in the affected ground-water areas of the Territory (State).
>
> 2. (The Board may) authorize any affected territorial (State) or local government agency or public water supplier to enter upon public or private lands in any ground-water area and remove any amount of ground-water necessary to protect the public health safety and welfare. . . .[68]

The Board of Land and Natural Resources has not yet designated a control area under the Ground Water Use Act. One reason for this is that voluntary agreements among water users have been working reasonably well. But although the Ground Water Use Act specifies the regulatory powers of the State, those powers remain untested.[69]

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[68] Hawaii, Regular Session, 1959, Act 274; Regular Session, 1961, Act 122.

In writing the Ground Water Use Act in 1959, the Legislature clearly rejected the idea advanced by Wells Hutchins and Frederick Ohrt in the middle and late 1940's that Hawaii's ground waters should be declared public property. This proposal was rejected as an unjustifiable confiscation of a property right, the water underneath privately owned land. But all of Hutchins' and Ohrt's other suggestions were written into the Ground Water Use Act. The Act established a commission with full legal powers, including the power to regulate the withdrawal of ground water. The commission was granted authority not only on Oahu, as Hutchins and Ohrt had suggested, but throughout the Territory.

In the coming years, as demands on Hawaii's water resources rise, the Ground Water Use Act will become increasingly important for the conservation and regulation of this vital resource. The simple existence of the law promotes cooperation among potentially competitive water users. And in the event that conflicting claims cannot be resolved voluntarily, the law provides procedures for the equitable settlement of disputes over the allocation of ground water. Moreover, the law protects the public interest in the State's water resources. The men and women of the Thirtieth Territorial Legislature and the First State Legislature are to be commended for a farsighted and statesmanlike accomplishment: the passage of Hawaii's Ground Water Use Act.

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[69] Hawaii Water Resources Regional Study, Hawaii Water Resources Regional Plan (Honolulu: Hawaii Water Resources Regional Study, 1974), pp. 26, 27; Robert T. Chuck, interview, November 4, 1974.

The decade following World War II was marked by a return to normal operations for the Board of Water Supply, and by the appearance of new factors in Oahu's water supply situation. The population of Honolulu reached a wartime high of 268,000 in 1944. In the immediate postwar years population rose gradually to 277,000 in 1948, declined to 233,000 in 1952, and then began a steady rise throughout the end of the decade of the 1950's. The 1960 census showed 294,194 people living in the City of Honolulu.[70]

As one might expect, the demand for water fell off after the unprecedented demand of the wartime years. The Board had furnished an average of 38.2 million gallons of water per day in 1945. Demand showed a fairly steady decline to 32.1 million gallons per day in 1951, and then began to increase until by 1957 it exceeded the peak wartime load. The decline in demand in the immediate postwar years caught the Board in a financial squeeze: revenues were down, but construction and operating costs were going up. In order to maintain financial self-sufficiency, the Board increased domestic water rates to .24 per 1,000 gallons in 1947, and to .30 per 1,000 gallons in 1951.[71] The decline in demand brought improved conditions in Oahu's underground reservoirs. The artesian head measured at the Beretania Street station reached a low of 22.07 feet in 1946, but rebounded to 28.48 feet a decade later.[72]

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[70] Honolulu Board of Water Supply, Sixteenth Biennial Report, p. 77; Robert C. Schmitt, Demographic Statistics of Hawaii: 1778-1965 (Honolulu: University of Hawaii Press, 1968), p. 116.

The building of residential subdivisions gained momentum after the war. For several years the new subdivisions primarily accommodated people who had been crowded into Honolulu during the war years. But in the 1950's, as the population began to show a definite increase, it became clear that in-migration was fueling the expansion of subdivisions.

Honolulu's pattern of growth is shaped by the geography of southeastern Oahu. Residential growth occurs in the valleys, on the hillsides separating the valleys, and both easterly and westerly along the coast. The construction of residential subdivisions presents some difficult water supply problems. Water mains must be extended. And water pressure must be substantial enough for domestic needs and fire-fighting requirements. During the late 1940's, and

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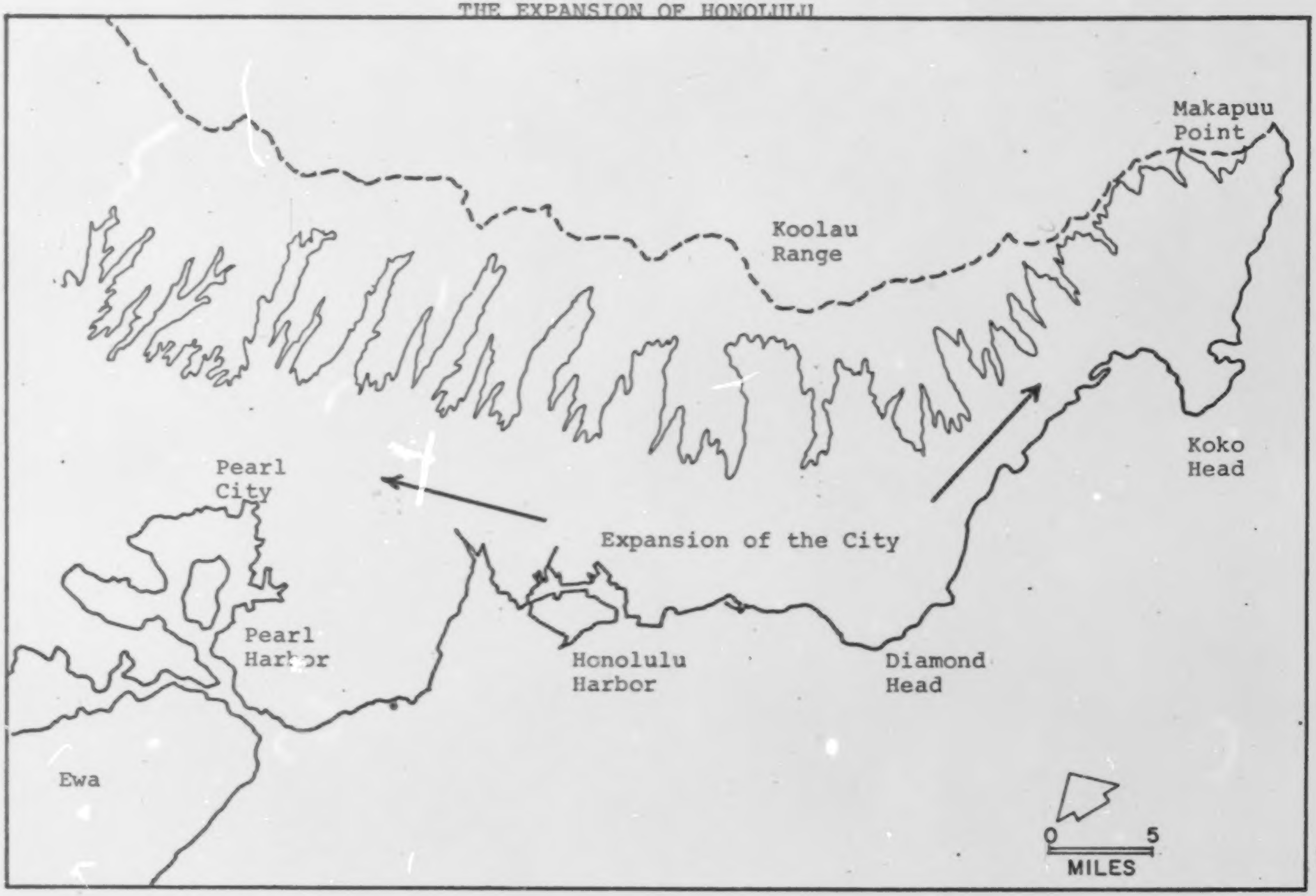
[71] Honolulu Board of Water Supply, Sixteenth Biennial Report, p. 72; Thirteenth Biennial Report, p. 69.

[72] Honolulu Board of Water Supply, Sixteenth Biennial Report, p. 69.

MAP 5

THE EXPANSION OF HONOLULU


Makapuu
Point
Koolau
Range
Koko
Head
Pearl
City
Expansion of the City
Pearl
Harbor
Honolulu
Harbor
Diamond
Head
Ewa
0
5
MILES

throughout the 1950's, the Board established a series of rules and regulations for supplying water to subdivisions. In some areas the Board placed limitations on the number of new services. In other cases the Board fixed the upper elevation limits for water supply throughout the City of Honolulu. Nonetheless, the BWS stood ready to revise these limits in areas where the construction of new reservoirs and pumping stations, and the extension of water mains assured an adequate water supply at higher elevations.

As far as the costs of new facilities were concerned, the Board's Thirteenth Biennial Report, 1951, outlined a policy for supplying water to residential subdivisions. The developer must install the water supply system according to BWS specifications. He then dedicates the facilities to the Board for BWS operation. The Board's Water Sales Division carries out any necessary negotiations with the subdivider, and the Engineering Division is responsible for making sure that the design of the new facilities meets the requirements of the Board of Water Supply. An interview with Richard Lum of the Planning, Resources and Research Division confirmed that the policy outlined above is still in effect.[73]

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[73] Honolulu Board of Water Supply, Thirteenth Biennial Report, pp. 28, 29; Fifteenth Biennial Report, pp. 32, 33; Honolulu Board of Water Supply, Rules and Regulations of the Board of Water Supply Covering Water and Water System Requirements for Subdivisions in the City and County of Honolulu (Honolulu: Honolulu Board of Water Supply, 1949); interview with Richard W. K. Lum at the Honolulu Board of Water Supply, January, 1974.

From January, 1951, to December, 1958, the Board of Water Supply processed applications for subdivisions totaling over 16,800 new lots. Honolulu grew, and the Board supplied water to such new residential subdivisions as Wailupe, Waialae-Kahala, Aina Koa, Foster Village, Niu Valley and Maunalua.[74]

The year 1959, was an especially important one for the Board of Water Supply. The Board's Chairman, Ralph E. Clark, was not exaggerating when he wrote that "1959 will take its place as probably the most significant in growth and certainly one of the most vigorous in terms of planning and construction in the history of the Board of Water Supply."[75] Two events were especially noteworthy: Statehood and the acquisition of the Suburban Water System. The granting of Statehood meant that the economy and the population would grow at unprecedented rates, and the BWS would be challenged as never before to meet the water supply needs of Oahu's people. Inexpensive transportation by jet aircraft brought Hawaii within the financial reach of hundreds of thousands, then millions, of visitors from the mainland. Jet aircraft technology, in effect, made contemporary Waikiki, with its high rise hotels, condominiums, restaurants and recreational facilities a possibility and then a reality. Newly opened Ala Moana Center symbolized Hawaii's affluence, and the State's full participation in the economic life of the United States and the Pacific region. Steel for the booming construction industry rolled off the line at Hawaiian Western Steel Company's new mill. Permanente Cement and Standard Oil geared up their facilities to go into operation in 1960. This was just the beginning of a new era in the development of Oahu. And all of the new industries, new activities and new people would require water from the Honolulu Board of Water Supply.

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[74] Honolulu Board of Water Supply, Fifteenth Biennial Report, p. 32; Sixteenth Biennial Report, p. 35; Seventh Biennial Report, p. 16.

[75] Honolulu Board of Water Supply, 1959 Annual Report (Honolulu: Honolulu Board of Water Supply, 1959), p. 4.

The effect of Statehood on Oahu's water requirements would increase with the passage of time. But there was an immediate impact on BWS operations when the Board acquired the City and County's Suburban Water System. As early as 1939, Frederick Ohrt had proposed the transfer of the Suburban System to the Board in order to finance the Suburban System's $75,000 annual deficit. The main reason the Suburban System operated in the red was because population was relatively scattered in the rural districts. The Suburban System lacked the concentration of customers needed to meet the costs of water supply facilities and long transmission lines. After World War II, the suburban districts nearest Honolulu experienced significant growth. And the Suburban System was hard pressed to keep up with demand. In 1957, the Legislature authorized the City and County to issue

$3,000,000 worth of general obligation municipal bonds to modernize and expand Oahu's rural water supply system.[76]

In December, 1958, the Board of Supervisors passed a resolution combining the Suburban Water System with the Board of Water Supply. The transfer took place on January 1, 1959. Within two weeks, Manager and Chief Engineer, Edward Morgan, announced a five year, $7 million water supply expansion program directed primarily at meeting the urgent needs of rural Oahu.[77]

At the time of the transfer there was a minimum of discussion about the inadequacy of the Suburban System. The Board welcomed the employees of the former Suburban System, and expressed confidence about its ability to carry out its new responsibilities. But the situation was deteriorating badly in the suburban and rural areas. Within a year of the transfer, Edward Morgan announced that $7 million was not enough money to modernize and expand the suburban system. He suggested that a six year, $12½ million program would be needed in order to avoid serious water shortages.[78]

In 1961, Morgan acknowledged that the development of water supply facilities in suburban and rural Oahu had fallen five years behind in meeting water supply needs. A year later, Morgan confirmed that the suburban-rural situation was a severe challenge to the Board's ability to meet its responsibilities. George Yuen, then Manager of Field Operations, recalled that the water mains in Windward Oahu were inadequate to meet demand and that the Board had to resort to a voluntary conservation program for a brief period in 1960.[79]

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[76] Honolulu Star-Bulletin, February 28, 1939, p. 2; Honolulu Advertiser, January 13, 1959, p. A1.

[77] Honolulu Board of Water Supply, Seventeenth Biennial Report, p. 7; Honolulu Advertiser, January 13, 1959, p. A1.

[78] Honolulu Board of Water Supply, 1959 Annual Report, p. 17.

During the early 1960's the Board struggled to stay ahead of demand. The following projects were designed to meet suburban and rural water supply needs:

1. 28,000 feet of water main from Castle Junction to Waimanalo.
2. 19,000 feet of main for the Waianae region.
3. 12,000 feet of main for Wailua-Kawailoa.
4. 6,900 feet of main for Kaaawa.
5. 6,900 feet of main for Kailua-Enchanted Lakes.
6. A new 2 million gallon capacity reservoir for Wahiawa, and smaller reservoirs for Halawa-Aiea and Waipio.
7. Two new 1.2 million gallon per day pumps for Manana Pumping Station in Pearl City.

New facilities were put into operation and older units were overhauled throughout the Island. The Board's annual capital expenditures averaged more than $5 million, about twice the annual rate of the previous decade.[80]

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[79] Honolulu Board of Water Supply, Annual Report, 1961, p. 3; Honolulu Board of Water Supply, Annual Report, 1962, p. 5; Honolulu Star-Bulletin-Advertiser, July 11, 1965, p. B6.

By 1966, the situation had improved. The following statement by Edward Morgan indicates the effect of the suburban-rural water supply situation on the Board:

> Since January 1, 1959, . . . our main emphasis has necessarily been directed to the development of new supplies and the enlargement of distribution facilities in suburban areas. This far-reaching program, entailing expenditure of millions of dollars and thousands of man hours, was of prime importance in enabling these communities to grow and keep pace with the fast developing economy accelerated by Statehood. . . . While we are not entirely 'out of the woods,' . . . the enormous strides of the past seven years have allowed somewhat of an easing of the intense pressures on the department to meet the challenge of providing adequate water service for Honolulu and its environs in the face of greatly increased demands.[81]

Graphs depicting the unprecedented growth that has taken place since 1959 may be found at the end of this chapter. The following map indicates the expansion of the

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[80] Honolulu Board of Water Supply, Annual Report, 1962, pp. 6, 7, 10; Honolulu Board of Water Supply, 1962-63 Annual Report, pp. 8, 9, 13; Honolulu Board of Water Supply, Annual Report, 1963-64, pp. 9, 11.

[81] Honolulu Board of Water Supply, Annual Report, 1965-66, p. 6. A report by the Board's Water Sales and Service Division entitled "A Summary of Principal Private Water Systems of Oahu," released in September, 1974, shows that as the urbanization of Oahu has proceeded, a number of small and usually inadequate private water systems have been abandoned in favor of municipal water supplied by the BWS. Fire fighters and public health officials are especially gratified by this trend. Several plantations and military establishments as well as the State Hospital in Kaneohe continue to maintain private water systems. At present, there are no plans for incorporating these facilities into the BWS system.

Board's area of responsibility since the acquisition of the Suburban Water System in 1959.

In addition to suburban-rural water supply activities, the Board had to continue to meet its commitments within the District of Honolulu. One index of Oahu's growth during the early 1960's was that subdividers requested water supply facilities for more than 6,000 new homes per year, more than double the rate of the previous decade.[82]

Another indication of future demand was the rise of the number of large size meters (3 inches or more) installed for domestic use by the Board. The large meters were installed in middle and high rise apartment and condominium buildings. A major conservation problem occurs with the installation of large numbers of these meters because the individual resident generally never sees a statement of charges for the water he has consumed. Billing is done on the basis of the single large meter serving the entire building. So there is little incentive for the individual resident to conserve water.[83]

In response to increasing demand, the Board undertook a comprehensive study of Oahu's water resource and the

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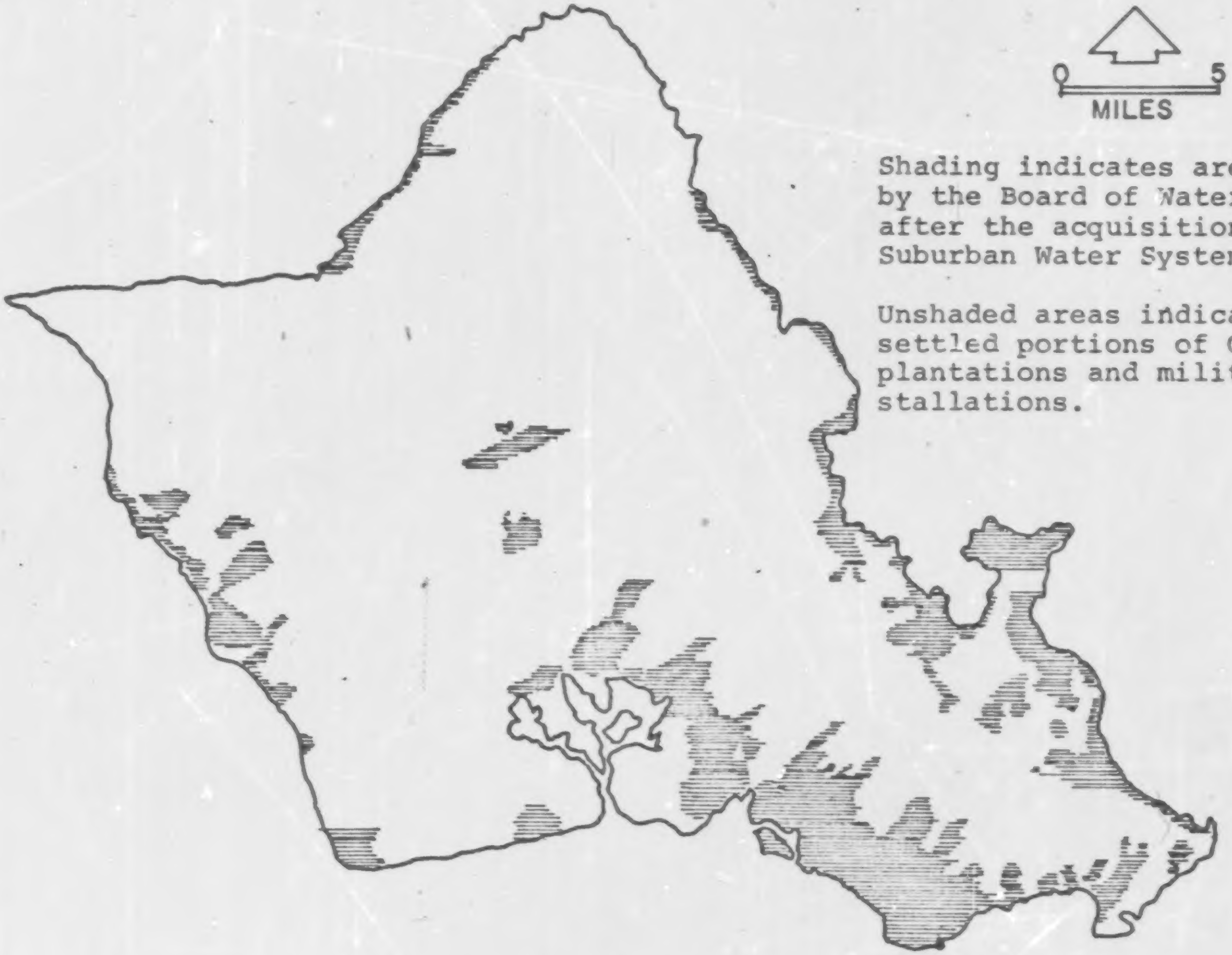
[82] Honolulu Board of Water Supply, Annual Report, 1962, p. 12; Honolulu Board of Water Supply, Annual Report, 1963-1964, p. 8; Honolulu Board of Water Supply, Annual Report, 1964-1965, p. 6.

[83] Honolulu Board of Water Supply, Annual Report, 1962-1963, p. 17; Jacob Chu, "Water Use in Urban Areas," speech delivered at the Water For Hawaii Conference, Princess Kaiulani Hotel, Honolulu, January 31, 1974.

MAP 6

AREAS SERVED BY THE BOARD OF WATER SUPPLY AFTER 1959



Shading indicates areas served by the Board of Water Supply after the acquisition of the Suburban Water System in 1959.

Unshaded areas indicate unsettled portions of Oahu, plantations and military installations.

demands that the future would bring. This Oahu Water Plan was completed in March, 1963. The Plan projected the Island's water needs to 1980. It anticipated a "very large increase in consumption . . . due to both an expanding population and industrial base, and to greater individual demands."[84] The Plan predicted that per capita consumption would increase to 180 gallons per day by 1980, and the Board would be required to provide an average of 126 million gallons of water per day by that same year.[85] As a matter of fact, the Oahu Water Plan underestimated the growth of demand on the water supply system. Per capita consumption began to exceed 200 gallons per day as early as 1970, and just over 126 million gallons of water were supplied by the Board on an average day in 1973. Despite its predictive shortcomings, the Oahu Water Plan was the first significant attempt to compile a comprehensive plan for the development of Oahu's water resources.

One of the Plan's recommendations was that additional water for Honolulu must be imported from south-central Oahu. The Plan emphasized the wealth of water resources in the Pearl Harbor region, and stated that the continued growth of Honolulu would depend upon an abundant supply of water from the Halawa-Pearl Harbor-Pearl City area.[86] In July, 1963, the Board began to develop new water sources in Kalauao Valley, west or Ewa, of Halawa and Aiea. The Kalauao Project involved the drilling of four deep wells, the construction of a pumping station, and the laying of two miles of 36 inch pipeline. The Project was expected to develop 10 million gallons of water per day for Honolulu.

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[84] Honolulu Board of Water Supply, Oahu Water Plan, p. 10.

[85] Honolulu Board of Water Supply, Annual Report, 1962-1963, pp. 6, 7.

Kalauao marked the second occasion that the Board had reached outside the District of Honolulu to provide water for City use. The first step outside the District had been the Halawa Valley Project built during the high demand years of World War II. Twenty years elapsed between the Halawa Project and the development of Kalauao water. But the Kalauao Project marked the acceleration of an important trend: the development of increasingly distant sources, and the transmission of water to Honolulu over increasingly longer pipelines. Along with the description of the Kalauao Project in the Annual Report, 1963, the Board announced future plans for new wells in Waiau and Waimalu Valleys, just Ewa of Kalauao Valley. The six deep wells at Waiau-Waimalu, with a pumping facility at Punanani Gulch, went into operation in 1972. The Punanani Project augmented the City's supply by an additional 12 million gallons of water per day.[87]

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[86] Honolulu Board of Water Supply, Oahu Water Plan, p. 64.

Meanwhile, plans were underway for a new well field at Punaluu on the Windward side of the Island. Work began on the Punaluu Project in 1965 and was completed in 1968. The Project consists of six wells, a pumping station and seventeen miles of transmission mains. The Punaluu well field develops 10 million gallons of water per day, intended primarily for the fast growing communities of Kaneohe and Kailua. The completion of the Punaluu Project gave the Board a fully integrated distribution system from Waimanalo to Kauula, a distance of about 34 miles.[88]

In June, 1973, the Island-wide integration of the water supply system came closer to realization with the completion of a 36 inch transmission main around Makapuu Point. This connection gave the Board's distribution system increased flexibility; it became possible to bring Windward water to Hawaii Kai and eastern Honolulu.[89]

The Board's 2020 Plan, published in 1971, makes it clear that the integration of the Island-wide distribution system will continue. It calls, for example, for the construction of a transmission main around Kaena Point. Moreover, the 2020 Plan recommends the development of well fields in suburban and rural localities all around the Island: at Waiahole, Kahaluu, Haiku, Waikane, Laie, Hauula, Kahuku, Waialua, Mokuleia, Wahiawa, Schofield-Mililani and Makaha. These new well fields will supply water for local needs, and many of them will contribute water to the Island-wide distribution network for export to high demand areas. Honolulu is reaching farther and farther for ample supplies of high quality water. Demands increase, but the Island's natural ground water supplies are finite. As Honolulu reaches farther afield for fresh water, it approaches an environmental limit to growth.[90]

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[87] Honolulu Board of Water Supply, Annual Report, 1972, p. 6.

[88] Honolulu Board of Water Supply, Annual Report, 1964-1965, p. 7.

[89] Honolulu Board of Water Supply, Annual Report, 1973, p. 6.

The Board of Water Supply has made a continuing commitment to research since the preparation of the Oahu Water Plan in the early 1960's. One reason for this commitment was the Board's awareness that Oahu's ground water supply is limited, and that alternative sources and methods of water use must be investigated as possible supplements. A second reason for the Board's involvement in research was that water supply problems, drought conditions in major cities, and the widespread pollution of waterways received nation-wide attention in the early and middle 1960's. The Federal Government saw research as a basic factor in solving a broad spectrum of water-related problems. A third reason was that the Board's research effort received increasing support from the U.S. Geological Survey and the newly created Water Resources Research Center at the University of Hawaii.

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[90] Honolulu Board of Water Supply, 2020 Plan (Honolulu: Honolulu Board of Water Supply, 1971).

Edward J. Morgan died in September, 1967. The following month, the Board appointed George Yuen, Manager and Chief Engineer of the Board of Water Supply. Mr. Yuen was strongly committed to expanding the Board's research program. In 1968 he announced the beginning of a ten year research program to investigate the following:

1. Salt water encroachment on the basal fresh water lens.
2. Recharge of the ground water supply.
3. The effects of urban development on recharge.
4. Saline water conversion.
5. Waste water reclamation.
6. Dike storage potential in the Koolau Mountains.
7. Water quality.
8. Spring flow.
9. And watershed management.[91]

Mr. Yuen expressed a desire to cooperate with the U.S. Geological Survey and the University of Hawaii in this research program. But he emphasized the unique character of the problems confronting BWS water resource managers, and he made it clear that the program was primarily an independent research project. Yuen expected the ten year effort to cost about two million dollars. It was to be funded within the Board's annual budgets, and Yuen felt that the series of studies would be well worth their cost in terms of benefits to BWS operations, management and water resource development.[92]

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[91] Honolulu Board of Water Supply, Annual Report, 1967-1968, pp. 7, 8.

To a considerable extent the new research program was a continuation of studies that had been considered routine since the days when Frederick Ohrt had been Manager and Chief Engineer. Nonetheless, the Board has sponsored several studies that have more than "in-house" significance:

1. A series of studies and reports extending from 1969 to 1973, by R. W. Beck and Associates on the Board's computer system, telemetry, supervisory control and data processing.
2. Feasibility and Economics of Dual Purpose Power-Desalting Plants, by Burns and Roe, Inc., 1971.
3. The 2020 Plan, 1971, essentially an update of the Oahu Water Plan of 1963.
4. "Economics of Urban Water Demand: A Case Study of the Honolulu Board of Water Supply," a Ph.D. dissertation by Ho-Sung Oh, 1973.

Since the early 1960's the Board has been committed to the development of an integrated, Island-wide distribution system. For the past decade, there has been emphasis on an expanded and largely independent research effort. The last several years have also seen the development of the Board's computer system (the writer will consider computer-related matters in detail in Chapter 4).

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[92] Ibid., p. 8.

Although the demand for an ample supply of fresh water has increased at an unprecedented rate since Statehood and the acquisition of the Suburban Water System, the Board's service to the public has been excellent. The question of the cost of this service to the public will be considered in detail in the following chapters.

The following graphs are presented to summarize this chapter:

1. Estimated Population Served by the Honolulu Board of Water Supply: indicates population growth on the Island of Oahu, and the effect of the acquisition of the Suburban Water System in 1959.
2. Number of Services: note the increase in 1959, and note that growth occurs more rapidly after 1959 than in years prior to Statehood and the acquisition of the Suburban System.
3. Water Main in Service: again, note the accelerated growth beginning in 1959.
4. HBWS Employees: note the effect of World War II when manpower was scarce; the two periods of most rapid growth are in the postwar years and in 1959 with the addition of most of the Suburban System's employees.
5. Per Capita Daily Water Consumption: per capita consumption increases with a rise in construction, as in the late 1960's and per capita consumption may decline in rainy years as people require less BWS water to irrigate their lawns and gardens. 1974 is an especially rainy year, hence per capita consumption is down. In the long run, per capita consumption can be expected to vary directly with the standard of living. A rising per capita demand for water is an indicator of community affluence.

6. Average Daily Water Delivery: this indicator of demand can be expected to rise as population and per capita consumption increase.

7. Net Worth: assets less depreciation, the net value of the Board's utility plant.

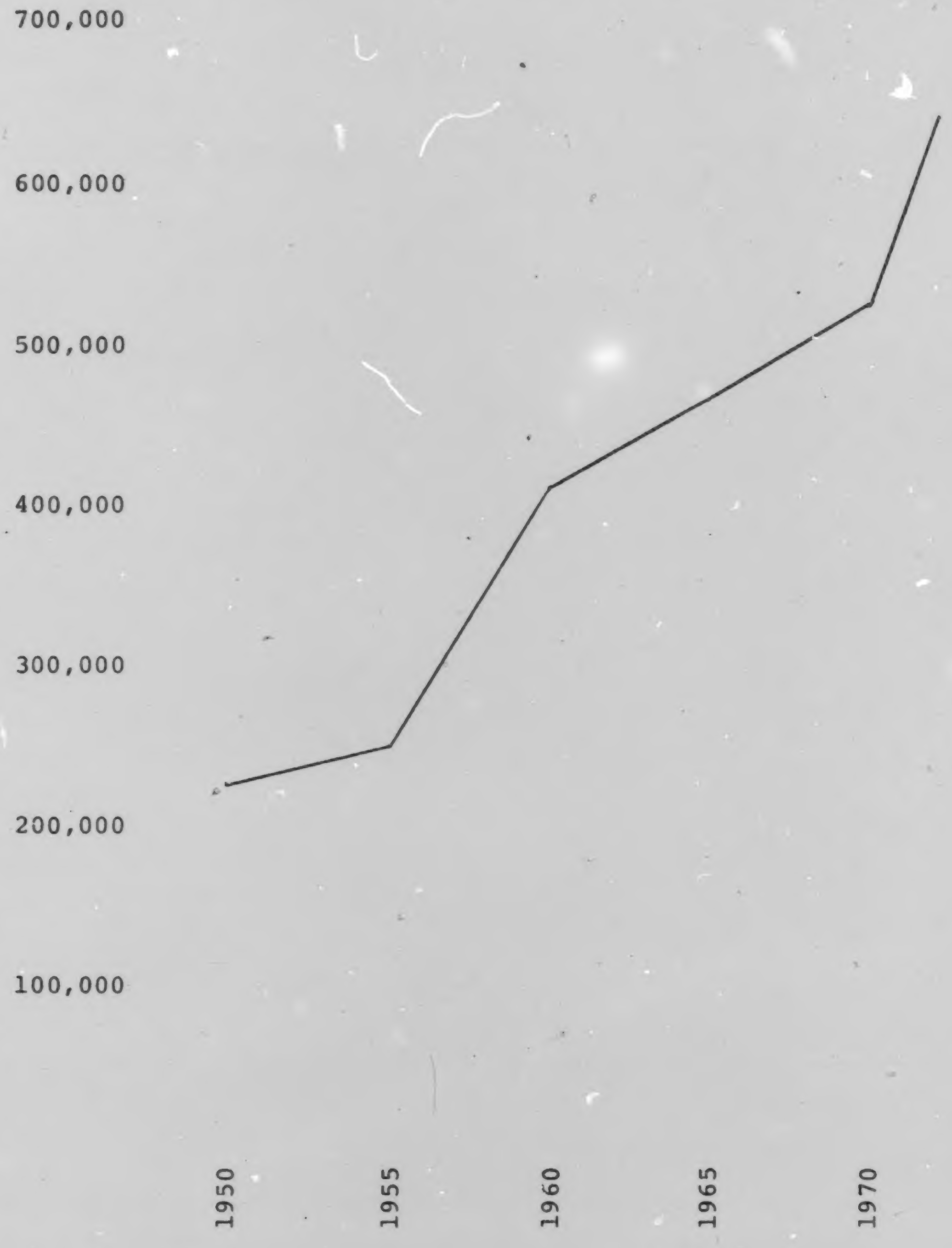
8. Operating Revenue: revenues have increased rapidly since Statehood, but operating revenue for fiscal year 1974 shows an unexpected decline.

9. Artesian Head: the measurement of the basal fresh water lens. A decline in the artesian head indicates that the fresh water supply is being overdrawn. Overdraft was especially severe during the high demand years of World War II. Artesian head tends to recover during periods of high rainfall. In the final analysis, this graph of the artesian head depicts an environmental limit to growth, the finite character of Oahu's ground water supply.

10. Annual Rainfall: note the dry period between 1957 and 1962. During those years the artesian head declined. During the three wet years that followed 1962, the artesian head showed some recovery. Interestingly enough, Honolulu may be experiencing some climatic change. The average annual rainfall at Lower Luakaha Station from 1890 to 1950 was 135.48 inches. But from 1950 to 1973, the average has been 121.99 inches. A question should be asked: are the Lower Luakaha figures representative of Island-wide and Statewide rainfall conditions? If so, do they indicate a long term climatic trend? If Hawaii is receiving less rainfall with the passage of time, there are clear long-range implications for both agriculture and water supply in the Hawaiian Islands.

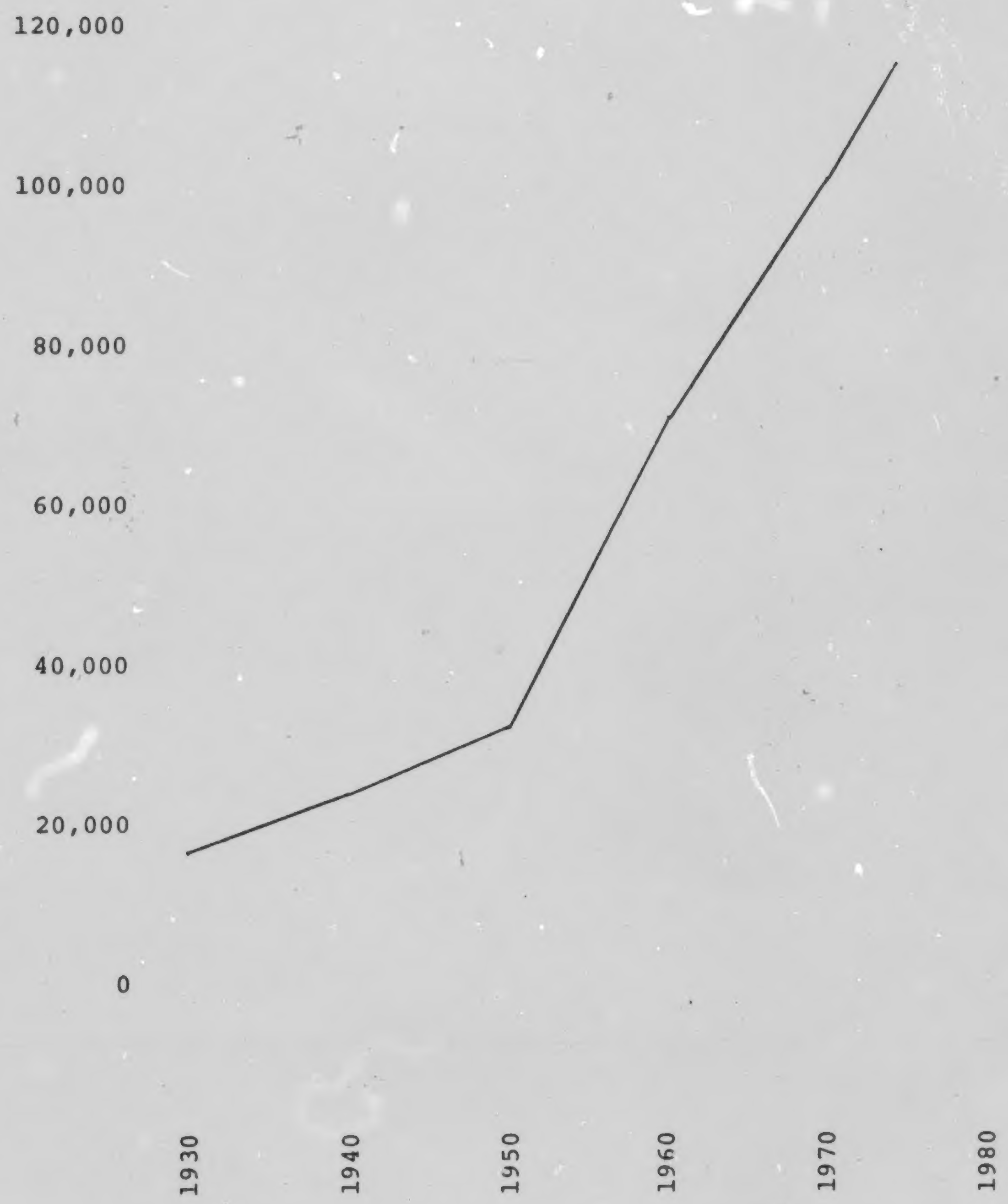
GRAPH 1

ESTIMATED POPULATION SERVED
Honolulu Board of Water Supply



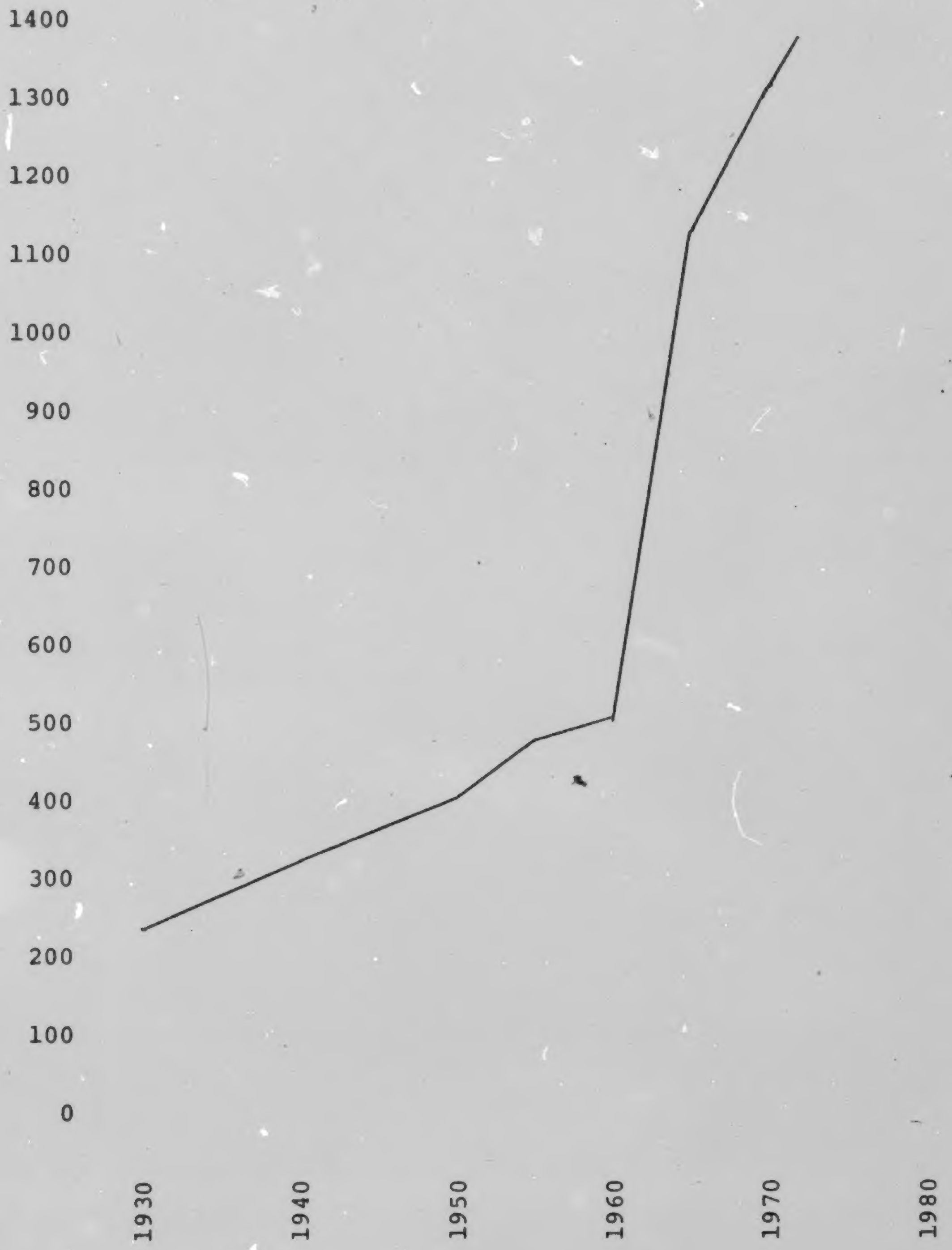
GRAPH 2

NUMBER OF SERVICES



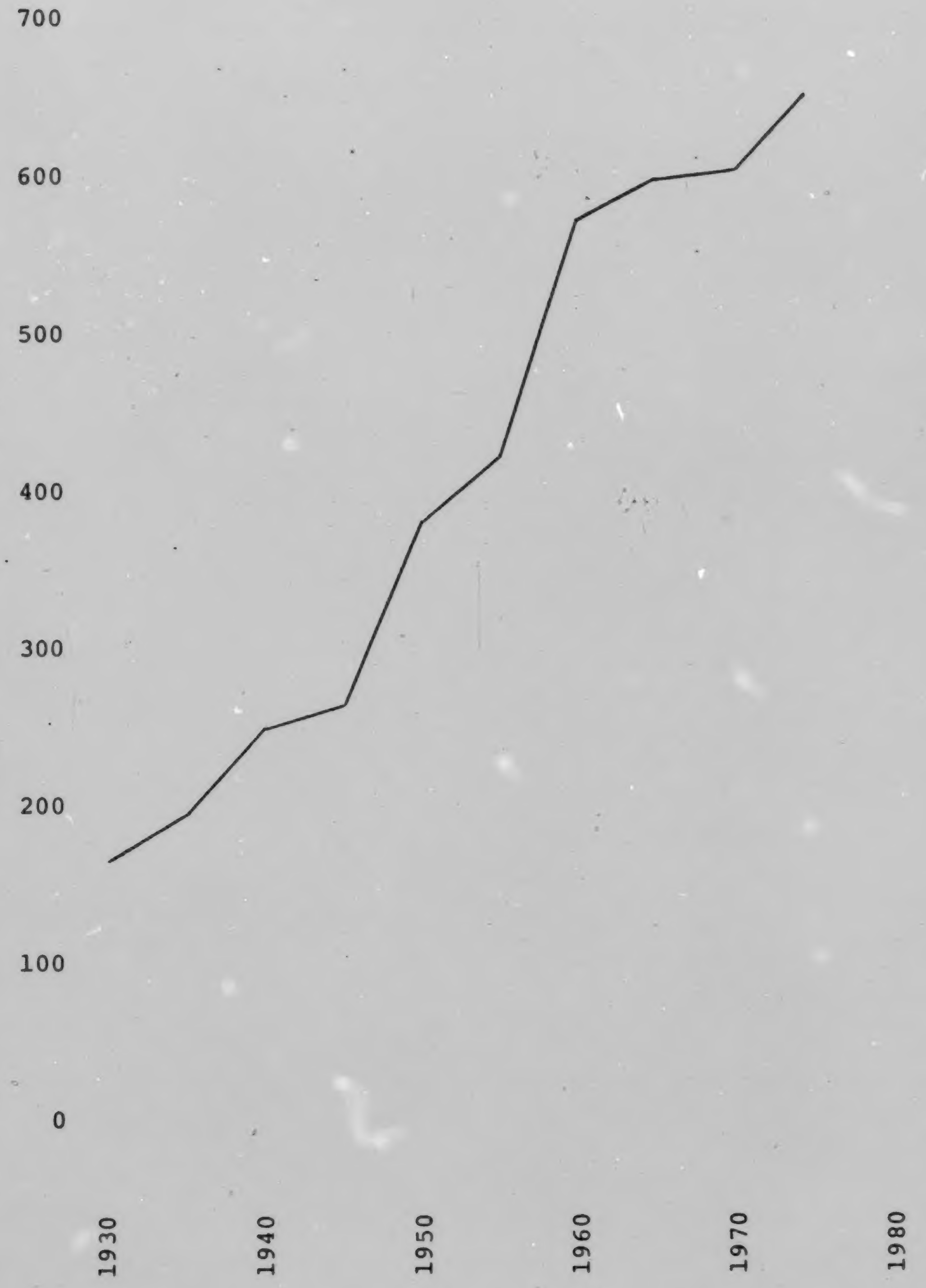
GRAPH 3

WATER MAIN IN SERVICE
in miles



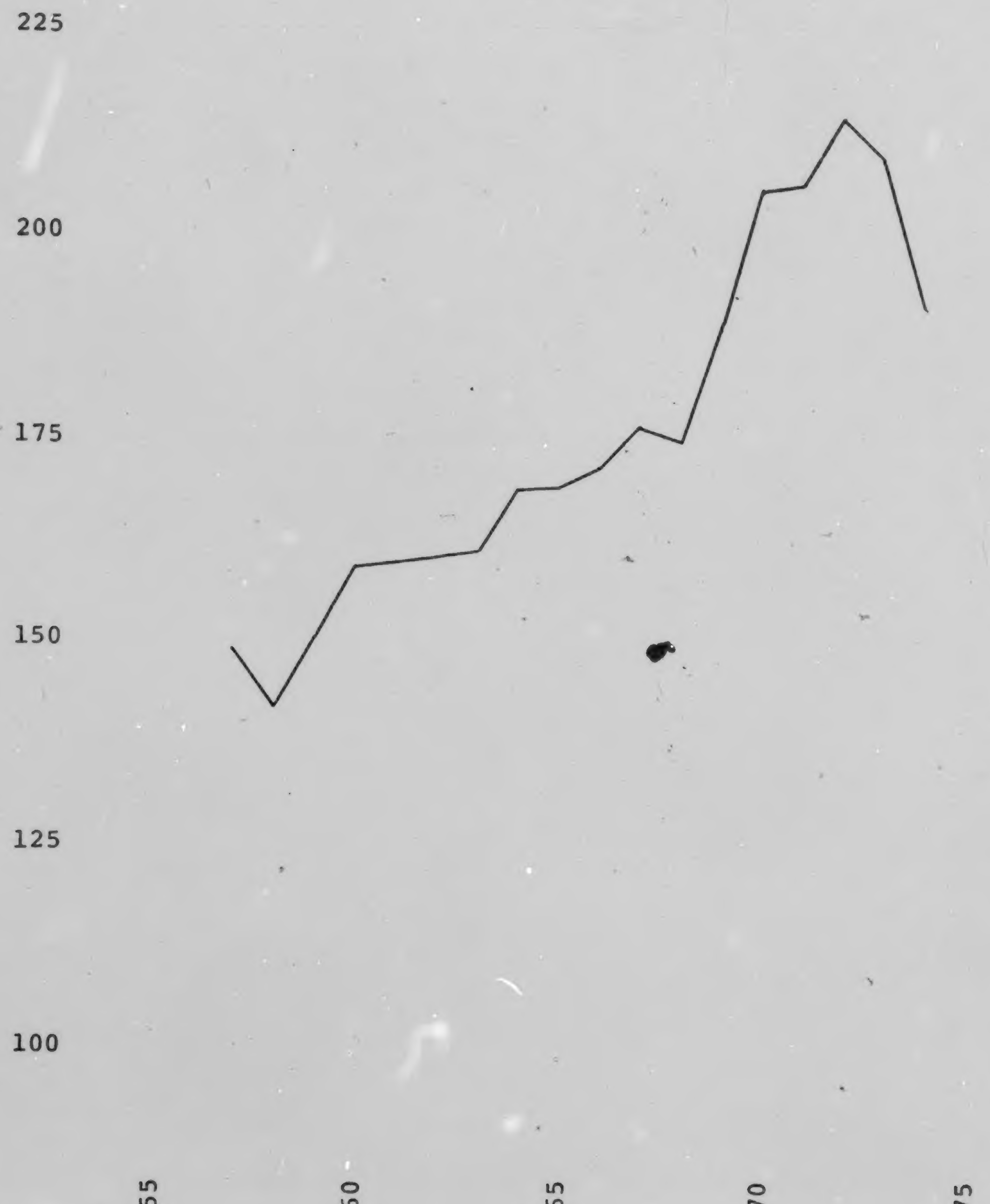
GRAPH 4

HBWS EMPLOYEES



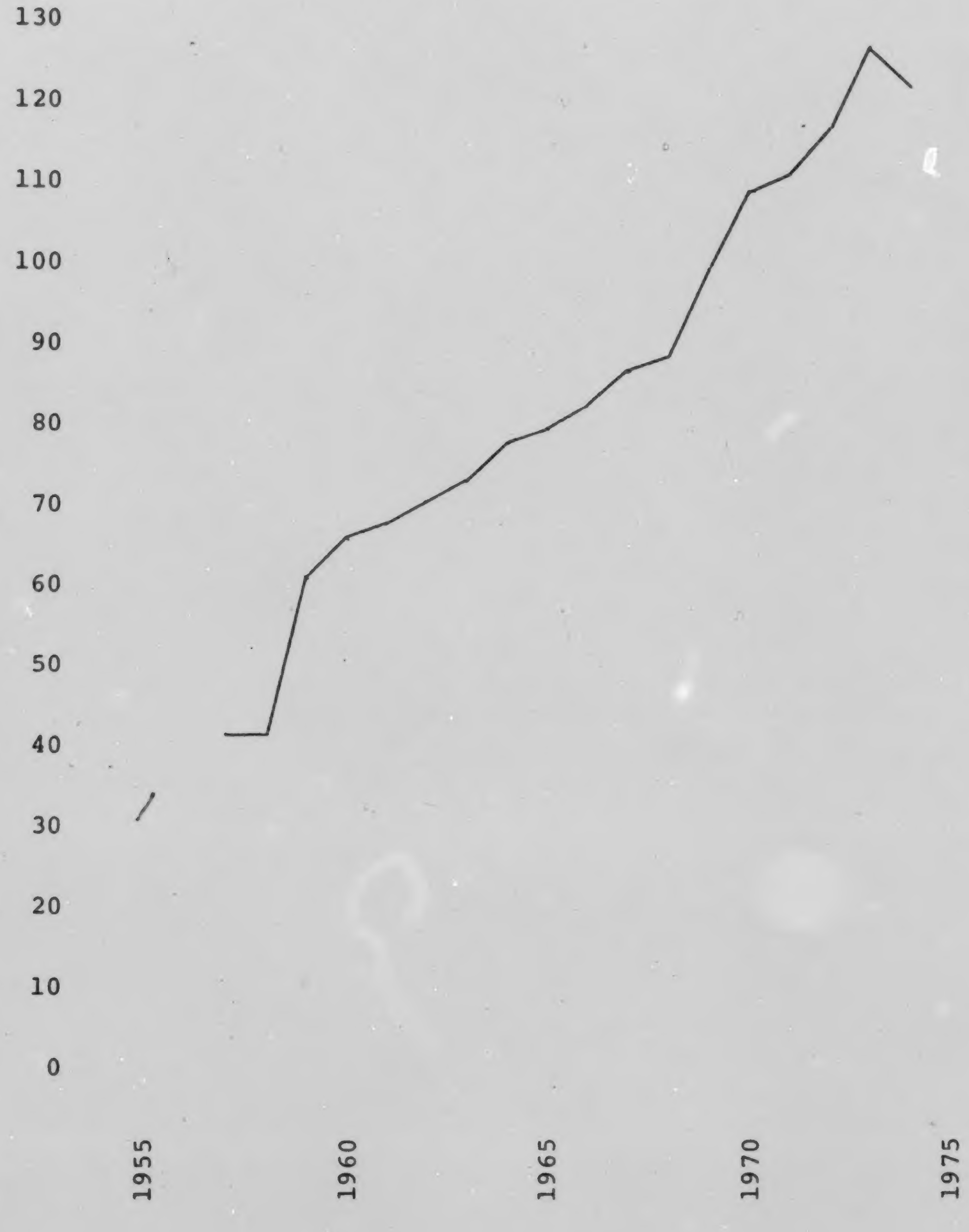
GRAPH 5

PER CAPITA DAILY WATER CONSUMPTION
in gallons



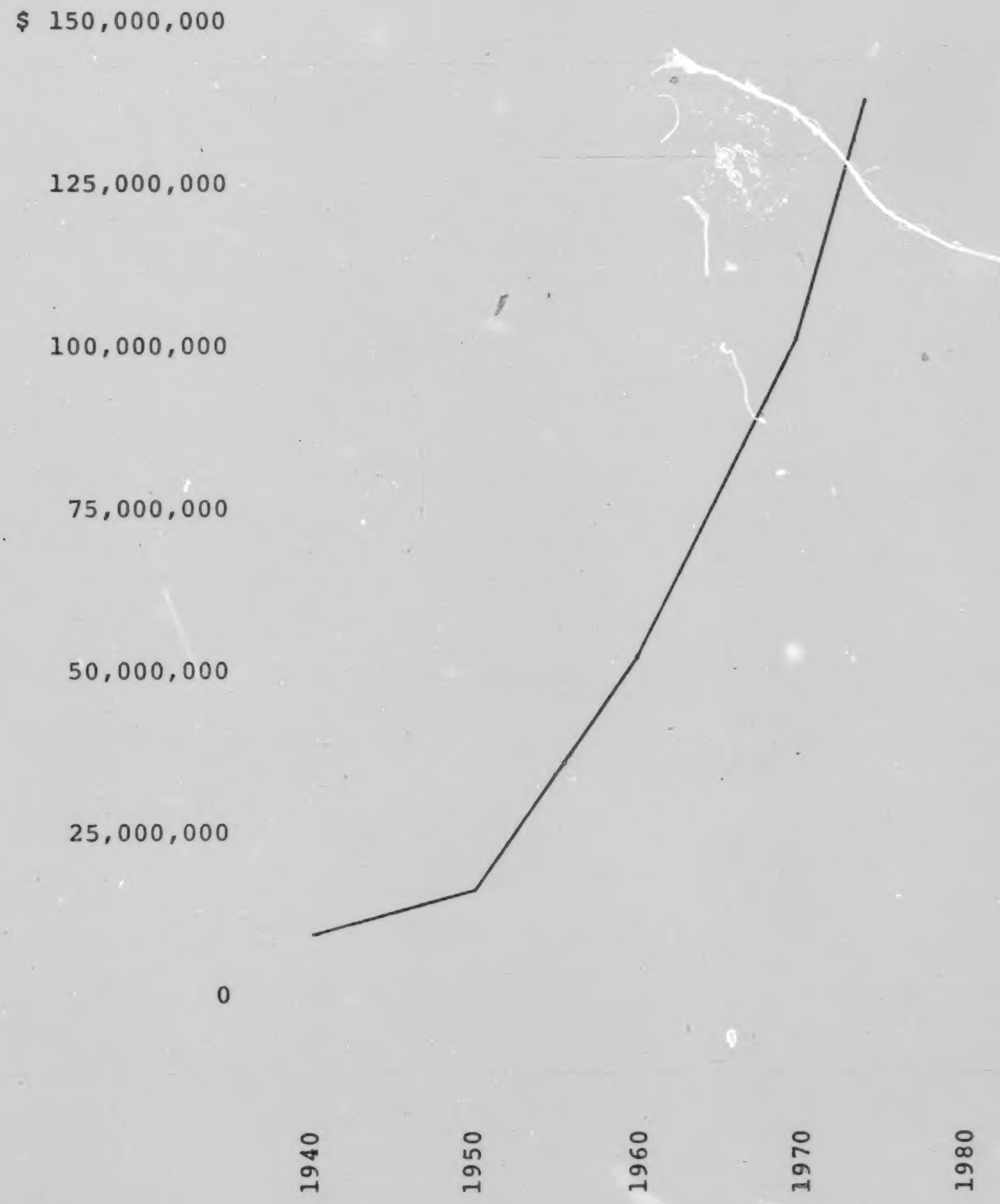
GRAPH 6

AVERAGE DAILY WATER DELIVERY
in millions of gallons



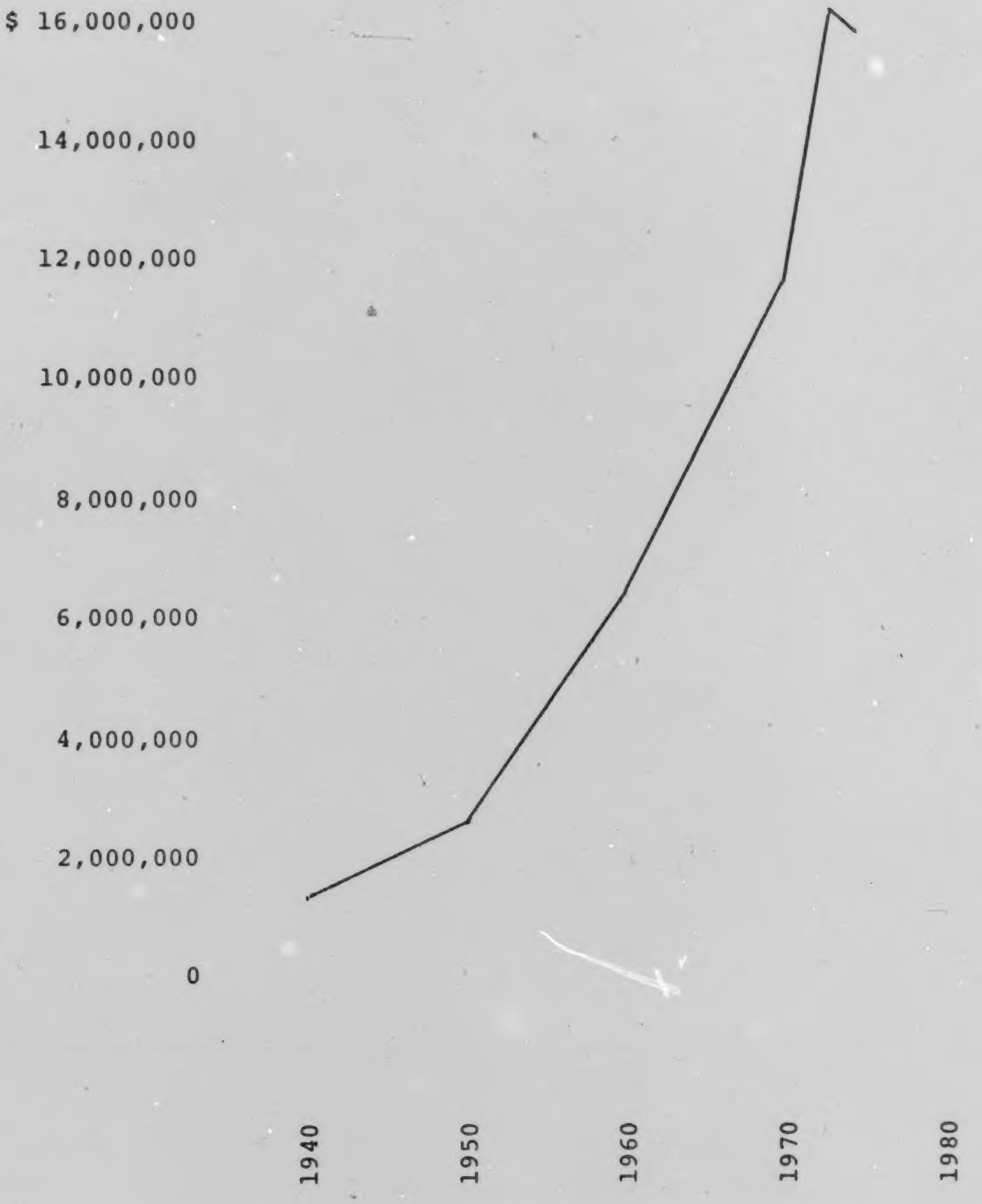
GRAPH 7

NET WORTH OF BWS



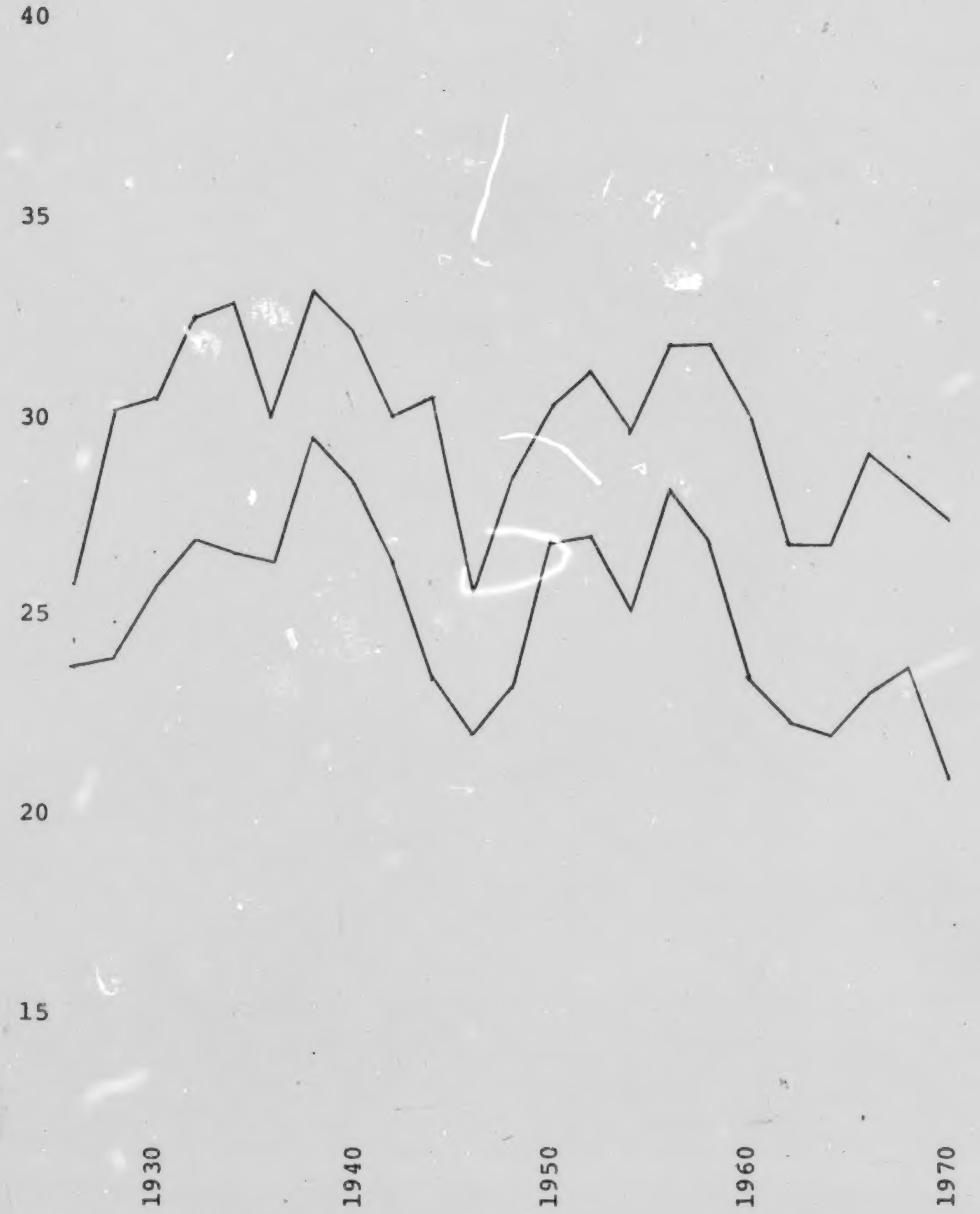
GRAPH 8

ANNUAL OPERATING REVENUE



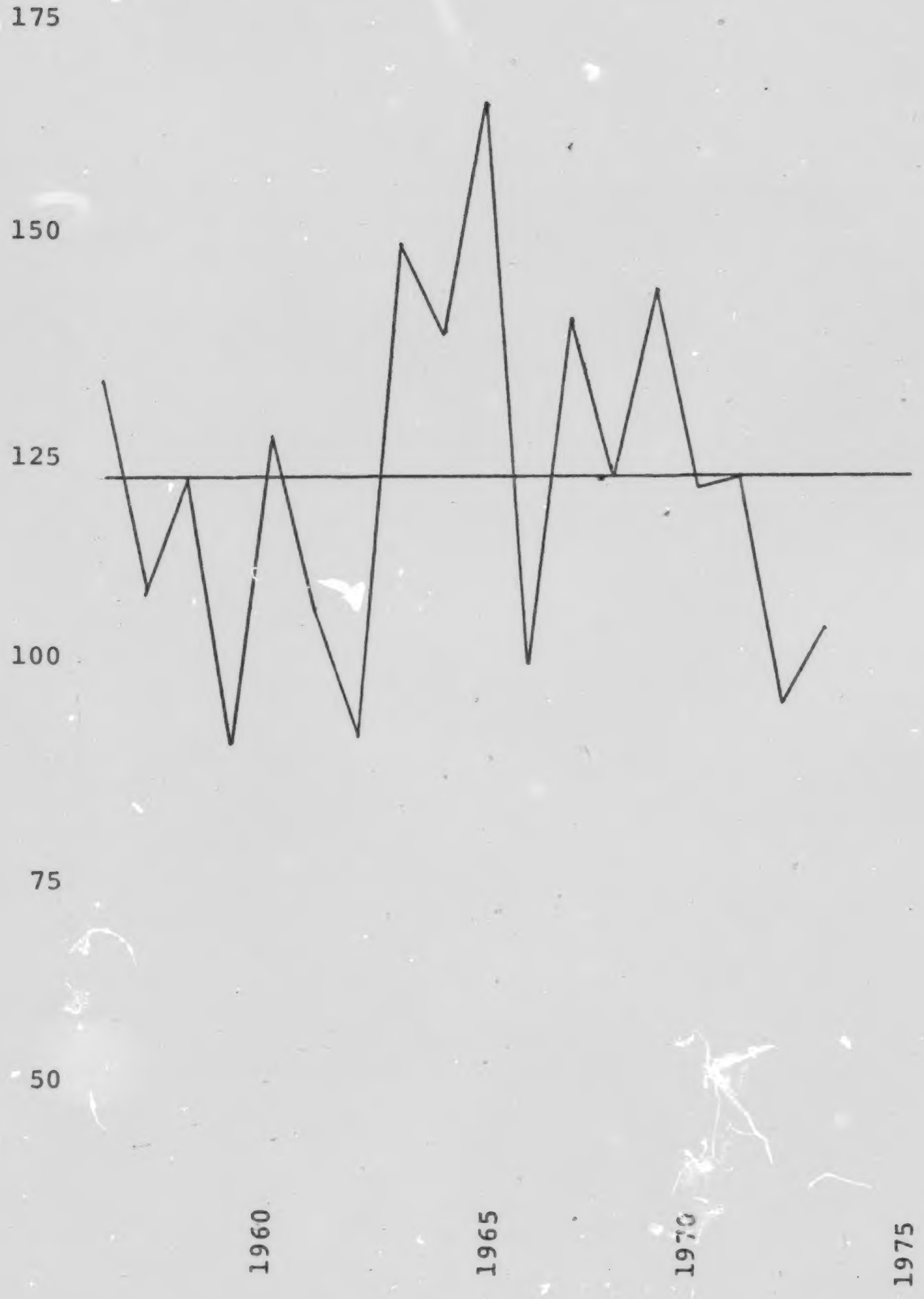
GRAPH 9

ARTESIAN HEAD
Beretania Street
Maxima and Minima, in feet



GRAPH 10

ANNUAL RAINFALL
Lower Luakaha, Nuuanu Valley
in inches



Chapter 3

PLANNING

The purpose of this chapter is to discuss the present water resource, population and land use situation on Oahu, and examine projects for the future.[1]

At the present time, Oahu is almost entirely dependent for its water resources on capturing rainfall in underground aquifers. Although approximately 1.8 billion gallons of rain fall on Oahu on an average day, only slightly more than one third enters the underground water supply.[2] The Board of Water Supply's 2020 Plan estimated in 1971 that an average of 700 million gallons of water per day enters the fresh water lens underlying the Island. In January, 1974, the

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[1] The writer wishes to acknowledge, early in this Planning Chapter, a considerable intellectual debt to Dennis L. Meadows and his associates at the Massachusetts Institute of Technology. Although their work, The Limits to Growth, has been criticized for various methodological shortcomings, their basic proposition, that there are environmental limits to growth and that man extends those limits at some risk to himself, remains valid.

[2] George A. L. Yuen, "The Impact of Economic Development of Demands for Groundwater and Wastewater Disposal--The Hawaiian Experience," address to the Circum-Pacific Energy and Mineral Resources Conference, Honolulu, Hilton Hawaiian Village Hotel, August 26, 1974.

Board revised this estimate downward to 642 mgpd.[3] Current technology permits the safe extraction of about 75% of the total, or 525 mgpd. However, the Board estimates that improved techniques will permit the extraction of at least 80%, or 560 mgpd, by the year 2000. These figures indicate the environmental limit of fresh ground water on Oahu. Technology may, of course, be used to extend this limit, and such technological options as desalination and recycling are described in Chapters 7 through 10 of this dissertation.

The present demand on Oahu's water resources is approximately 401 mgpd. This demand is distributed among four classes of water users as follows:

	(Million gallons per day)
Agriculture:	226
Board of Water Supply:	122
Military:	34
Private & Industrial:	19
	401[4]

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[3] 2020 Plan, p. 62; "Review of Oahu Conservation District Boundaries," Honolulu: Honolulu Board of Water Supply, January 31, 1974, Exhibit A: Discussion of Watershed Factors, p. 13. (Mimeographed.)

[4] Edward Y. Hirata, "Technical and Environmental Aspects of Using Municipal Sewage for Sugarcane Irrigation," address to the Conference of Hawaiian Sugar Technologists, Honolulu, Ilikai Hotel, November 13, 1974; Department of General Planning, City and County of Honolulu, Planning for Oahu: Analysis of Water and Wastewater Systems (Honolulu: City and County of Honolulu, March, 1974), pp. 11, 13.

If current technology permits a safe yield of 525 mgpd, and the total demand on the Island's water resources is 401 mgpd, then Oahu is clearly living within its water resources budget at the present time. However, two major qualifications must be made at this point. The first is that while the Island-wide water resources/water demand situation is satisfactory, two districts of the Island, Pearl Harbor and Honolulu, are experiencing a deficit in their water resources budget. In April, 1974, water resources consultant John F. Mink described the situation as follows:

> The hydrologic balance between input and output in southern Oahu is marginal at best. In reality a negative balance has become established in both the Honolulu District and the Pearl Harbor region in recent years, which if allowed to continue will in the long run cause deterioration in the quality of water withdrawn from the groundwater aquifers. In Pearl Harbor, particularly, a significant fraction of the pumped water (about 10%) is currently being obtained from storage in the lens. Unless draft is controlled, heads will continue to fall, spring flow will decrease and worsen in quality, and general disequilibrium will prevail. Overdraft also occurs in Honolulu, but the demand for additional production from its aquifers has quieted and it will be possible to bring about an optimal equilibrium.[5]

The basal fresh water lens that underlies Oahu is best thought of as a series of sub-lenses (with water flowing more or less freely in the general direction of the sea).

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[5] John F. Mink, "Water Supply and Demand in Southern Oahu," paper presented to the Oahu Water Users Association Conference sponsored by the Board of Water Supply on April 30, 1974: the situation in the Pearl Harbor watershed is discussed in detail in Chapter 9 of this dissertation.

Thus one, or several, artesian areas may experience an overdraft from high local demand while the Island's water supply as a whole is not overdrawn. Water resource managers have the option to overdraw and thus "mine" the ground water in a particular artesian area. This practice amounts to treating ground water like oil, coal or any other non-renewable resource.[6] Such a policy would satisfy short term demands, but would result in the continued deterioration and eventual destruction of the ground water resources in the particular region. The writer concurs with the second alternative suggested by John F. Mink in his report on the water resource situation in southern Oahu: water resource managers should determine an optimal regional equilibrium and restrict draft in order to achieve it.[7]

Water resource managers have the obligation to protect all of the Island's aquifers from prolonged overdraft. To do otherwise would be to mortgage the future of Oahu's water resources. Nature has endowed Oahu with a superb underground reservoir of fresh water. Water resource managers should develop this vital resource with the requirements of the future as much in mind as the needs of the present. This basically conservationist position forms the backbone of Chapter 177, Hawaii Revised Statutes (Hawaii's Ground Water Use Act). The writer believes that the provisions of

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[6] "Water Supply and Demand in Southern Oahu," p. 13.

[7] Ibid.

Chapter 177 should be put into effect whenever an artesian area is subject to deterioration from prolonged overdraft.[8]

The writer's first qualification concerning the generally satisfactory Island-wide water resources situation had to do with water resource deficits in southern Oahu. The second qualification concerns the future: how long will the water resources situation remain generally satisfactory? In other words, what is the carrying capacity of the Island of Oahu from the standpoint of water resources?

Three governmental entities, the State of Hawaii, the City and County of Honolulu, and the Board of Water Supply have developed projections of water resources supply and demand on Oahu. The writer will describe each of these efforts in detail.

The State Projection: In 1974, the Hawaii Department of Planning and Economic Development published the State of Hawaii Growth Policies Plan: 1974-1984. The Growth Policies Plan described four alternative futures for Hawaii:

1. Continuation of Existing Policies.
2. No Growth.

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[8] In Chapter 6 of this dissertation, the writer proposes the establishment of a State Environmental Protection Commission, and a Department of Environmental Protection intended to conserve water resources, regulate waste water disposal and protect the quality of Hawaii's environment. The writer believes that the Commission and the Department would provide the optimal institutional milieu for State-wide water resources planning.

3. Moderated Growth (Slowed Growth).
4. Accelerated Growth.[9]

The Growth Policies Plan described the effect of each of these alternatives on population growth, housing, transportation, agriculture, tourism and other employment bases. After examining the four alternatives in detail, the Department of Planning and Economic Development (DPED) recommended that the State choose the Moderated Growth option:

> In order to promote the public interest of the residents of the State of Hawaii, it is necessary to slow the rate of growth of the State's population, as well as to slow the rate of growth of certain sectors of the economy while accelerating the rate of growth in other sectors. This action is necessary to reduce (such) . . . growth-related problems (as) . . . over-reliance on tourism and Federal expenditures with increasing likelihood of severe State recessions, and problems arising from rapid population growth with heavy concentration on Oahu, including problems of increasing air and water pollution, rapid loss of agricultural land and open space, worsening traffic congestion, rising housing costs, and increasing per-capita costs of providing education and other public services.[10]

DPED concluded that Moderated Growth would provide Hawaii with the following benefits:

1. Sufficient economic activity to keep unemployment low.
2. A more diversified economy less subject to recession.
3. Improved air and water quality.

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[9] Department of Planning and Economic Development, State of Hawaii, State of Hawaii Growth Policies Plan: 1974-1984 (Honolulu: Hawaii Department of Planning and Economic Development, 1974).

[10] Ibid., p. 57; (original underlined as shown.)

4. Reduced housing and social service problems.
5. Lower energy requirements than under an Existing Growth or Accelerated Growth plan.[11]

Graph 11 on the following page, shows three population projections for Oahu. The high projection anticipates the Island's population under the Accelerated Growth option. The middle projection shows population growth under the Moderated Growth option, and the low projection was developed for the U.S. Water Resources Council by the U.S. Departments of Commerce and Agriculture.

The Hawaii Water Resources Regional Study expects the per capita demand for water to increase as follows:

Per Capita Demand on Oahu in Gallons Per Day

	Year					
Range	1970	1980	1990	2000	2010	2020
High estimate:	206	258	274	290	306	322
Medium estimate:	206	242	254	262	273	282
Low estimate:	206	236	242	248	254	260[12]

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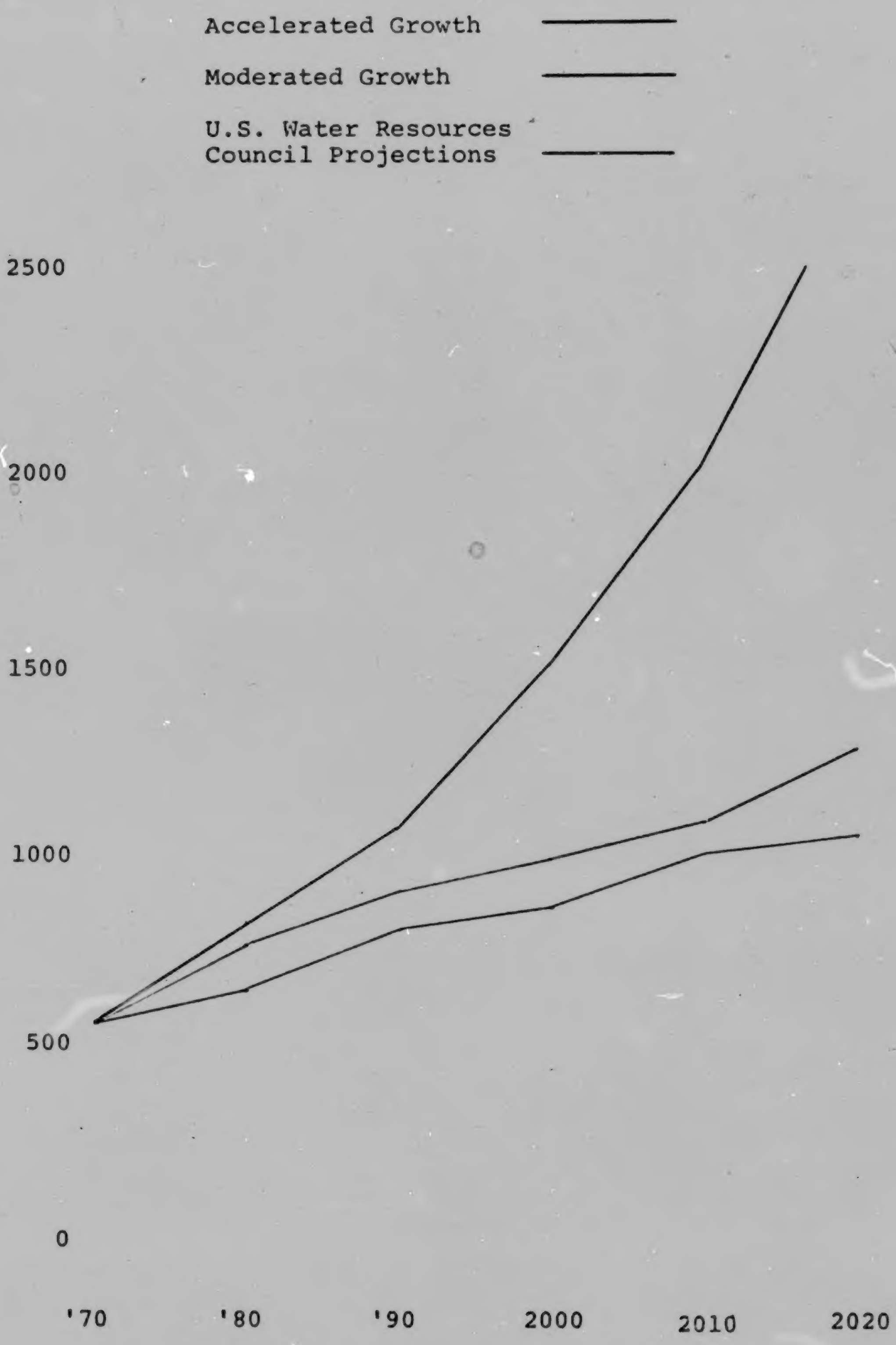
[11] Hawaii Water Resources Regional Study, Hawaii Water Resources Regional Plan (Honolulu: Hawaii Water Resources Regional Study, September, 1974), p. 38. The Hawaii Water Resources Regional Study is being carried out under the combined auspices of the U.S. Water Resources Council and the Hawaii Department of Land and Natural Resources. The September, 1974, publication cited here is the "First Cut" of the Hawaii Water Resources Regional Plan.

[12] Ibid., p. 53. Later in this chapter these projections will be compared with the Board of Water Supply's estimates of per capita demand on Oahu.

GRAPH 11

Oahu's Population (in thousands)



Planners obtained the following urban water demand projections by combining population estimates and per capita use estimates as follows:

Accelerated Growth Option

	1970	1980	1990	2000	2010	2020
Oahu's Population in 1000's:	631	798	1078	1474	2033	2820
Total Urban Use in Millions of Gallons of Water Per Day:	1970	1980	1990	2000	2010	2020
For High Per Capita Use:	130	206	295	427	622	908
For Medium Per Capita Use:	130	193	274	386	555	795
For Low Per Capita Use:	130	188	261	366	516	733

Moderated Growth (Slowed Growth) Option

			Year			
	1970	1980	1990	2000	2010	2020
Oahu's Population in 1000's:	631	757	853	963	1089	1235
Total Urban Use in Millions of Gallons of Water Per Day:	1970	1980	1990	2000	2010	2020
For High Per Capita Use:	130	195	234	279	333	398
For Medium Per Capita Use:	130	183	217	252	297	348
For Low Per Capita Use:	130	179	206	239	277	321

U.S. Water Resources Council Population Estimates

	Year					
	1970	1980	1990	2000	2010	2020
Oahu's Population in 1000's:	631	700	767	858	946	1024
Total Urban Use in Millions of Gallons of Water Per Day:	1970	1980	1990	2000	2010	2020
For High Per Capita Use:	130	181	210	249	289	330
For Medium Per Capita Use:	130	169	195	225	258	290
For Low Per Capita Use:	130	165	186	213	240	266[13]

The preceding tables project urban water demand. The following table indicates the supply on Oahu:

Distribution of Rainfall

Average Rainfall in millions of gallons per day	Ground Water	Surface Water	Lost to Evaporation and Transpiration
1800	687	455	Remainder

Sources of Supply

Level of Recovery	Ground Water		Surface Water		Total
	(%)	(mgpd)	(%)	(mgpd)	(mgpd)
High	85	584	50	228	810
Medium	80	550	40	182	730
Low	75	515	30	137	650[14]

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[13] Ibid., p. 53. The Hawaii Water Resources Regional Study estimates that agricultural water demand on Oahu will decline from 355 mgpd in 1970, to 295 mgpd in the year 2020, and remain constant at 295 mgpd through 2020.

[14] Ibid., p. 56. Water resource managers can bring about a movement from the present low level of water

The Island-wide water resources supply and demand situation is projected on Graph 12 on the following page.

The Hawaii Water Resources Regional Study estimates the years when projected water demand will exceed supply on Oahu as follows:

	Level of Growth		
	High	Medium	Low
Conservative:	1995	2013	2020+
Average:	2003	2020+	2020+
Optimistic:	2010	2020+	2020+[15]

In the opinion of the writer, the years cited in the preceding table are the best estimate of the time when the demand for water on Oahu will exceed the supply. The estimate takes into account the application of new ground water and surface water recovery technology, but it does not take into account such technological alternatives as desalination and waste water recycling. The use of these alternatives can further extend the environmental limits to growth on Oahu. Oahu will not "run out" of water in 1993, or 2000, or 2020, provided that water resource managers (in cooperation

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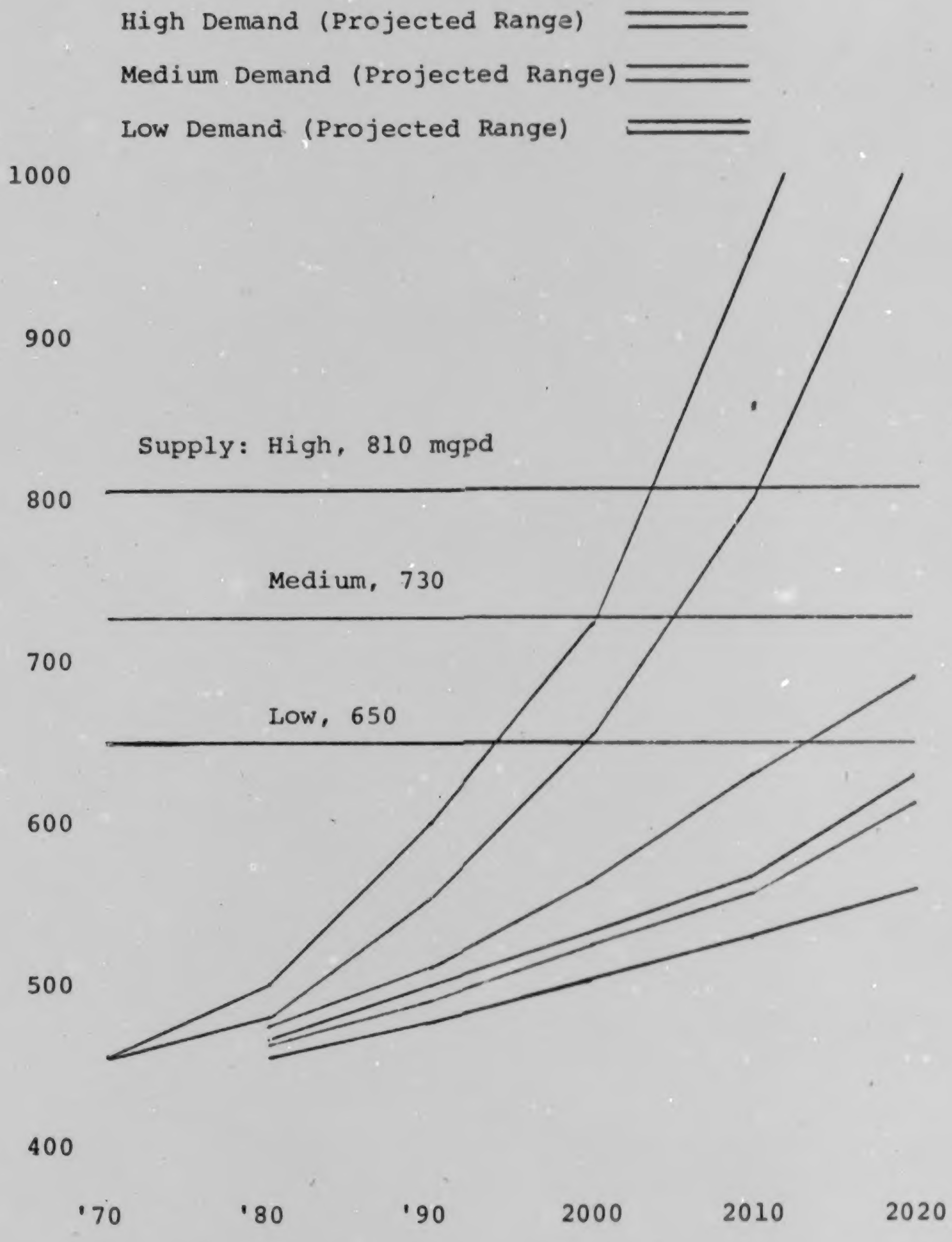
resource recovery to the medium level (anticipated by the year 2000) by applying ground water and surface water recovery technology. The application of existing and anticipated technology can be expected to augment the water supply at an increasing marginal cost; projects generating additional supply at the least unit cost will be undertaken first.

[15] Ibid., p. 60.

GRAPH 12

Water Supply and Demand on Oahu
(in millions of gallons per day)



with Federal, State and municipal government, and private industry) anticipate Oahu's water supply needs and implement the necessary technology.

Water resource managers have the responsibility to provide planners and decision makers with accurate estimates of the costs of supplementing the Island's natural water resources. As energy costs, and the costs of materials and construction rise, the community may choose to withhold the allocation of resources from the development of supplementary water resources. Although an ample supply of fresh water is necessary to the life of the community, the community may decide that it is preferable to limit the growth of demand on water resources rather than develop additional increments of supply at an ever increasing marginal cost.

All of the demand projections in this chapter assume an increase in the per capita consumption of water. Per capita consumption has increased with the affluence of the community. But the projections of ever increasing per capita consumption can be altered by sound public policy decision making. In Chapter 9 of this dissertation, the writer describes specific measures that decision makers and the community as a whole may take to conserve water and restrain the tendency toward ever increasing per capita consumption. The implementation of well conceived conservation measures would not adversely affect the quality of life in the middle and distant future. The writer is simply suggesting here that water resource managers should not accept projected trends as "givens" when such trends may, in the long run, be detrimental to the community. Effective public administration and resource management demand a willingness to shape the future in ways that benefit the community.

Thus far in the Planning Chapter the writer has described the State of Hawaii Growth Policies Plan (as it pertains to water resources), and the projections of the Hawaii Water Resources Regional Study. The writer now turns to the City and County of Honolulu and its General Plan Revision Program. Under the revised City Charter, accepted by the electorate in 1972, the General Plan is no longer to be merely a land use plan. The General Plan must become a statement of community objectives and it must recommend policies to obtain those objectives. The objectives pertain to housing, transportation, educational facilities, the supply and distribution of fresh water, waste water disposal systems, agriculture and recreation.[16]

The City and County Department of General Planning offered four sets of policy alternatives to achieve community goals. The four policies and their goal priorities are described as follows:

1. Intensive Development: Under the Intensive Development policy all future population growth and urban activities would be located within the present urban boundary as defined

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[16] Oahu Development Conference, An Evaluation of Alternative Residential Policies (Honolulu: Oahu Development Conference, October, 1974), pp. 1, 6.

by the General Plan adopted in 1964 and as revised since then.

Under this policy, the community chooses to implement land use controls as a means of preserving agricultural land.

The policy has an impact on population growth to the extent that housing would continue to be in short supply, and the cost of residing in Hawaii would continue to rise.

2. Moderate Expansion: This policy is basically a modification of Intensive Development. Moderate Expansion would permit residential construction outside of the urban boundary, and is designed to meet the housing needs of low and moderate income families. Residential development under Moderate Expansion would be primarily low density in character.

3. Private Sector Initiative: This alternative would continue the current practice of permitting the expansion of the urban boundary based solely on private sector development proposals.

   Private sector proposals would result in a high proportion of low density development, and would consume as much as 16,000 acres of agricultural land on Oahu by 1995.

4. Directed Growth: The Directed Growth policy would permit the use of from 10,000 to 13,000 acres of agricultural land for urban purposes by the year 1995.

   This policy would not restrict population growth. It would attempt to meet social needs in a controlled manner as they occur, until more selective means are found to influence growth.

   The Directed Growth Policy would create a population and employment center at Ewa. Residential densities would be relatively high, and the policy would encourage the development of a community of sufficient size to provide a full range of community services and activities.[17]

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[17] Ibid., p. 3-5.

The City Administration is moving ahead with the Directed Growth policy. On March 11, 1975, William Blackfield, Director of the Department of Housing and Community Development, announced a three year program designed to provide 5,000 new housing units for moderate income residents. Most of these new units would be located within the Ewa District.[18]

From the water resource perspective, the Intensive Development policy would be the least expensive to put into effect. On one hand, Intensive Development would hold the growth of population on Oahu down to approximately 924,000 by 1995. On the other hand, since most development would occur within present urban boundaries, there would have to be only minor additions to the water supply distribution system. Under Directed Growth, population is expected to rise to about 1.4 million by 1995, and major additions to the water supply distribution system would be necessary in the Ewa District.[19]

The Department of General Planning offers the projection of water supply and demand under the Directed Growth policy as shown on Graph 13.

In January, 1975, the Board of Water Supply published the Second Edition of the 2020 Plan. The 2020 Plan makes

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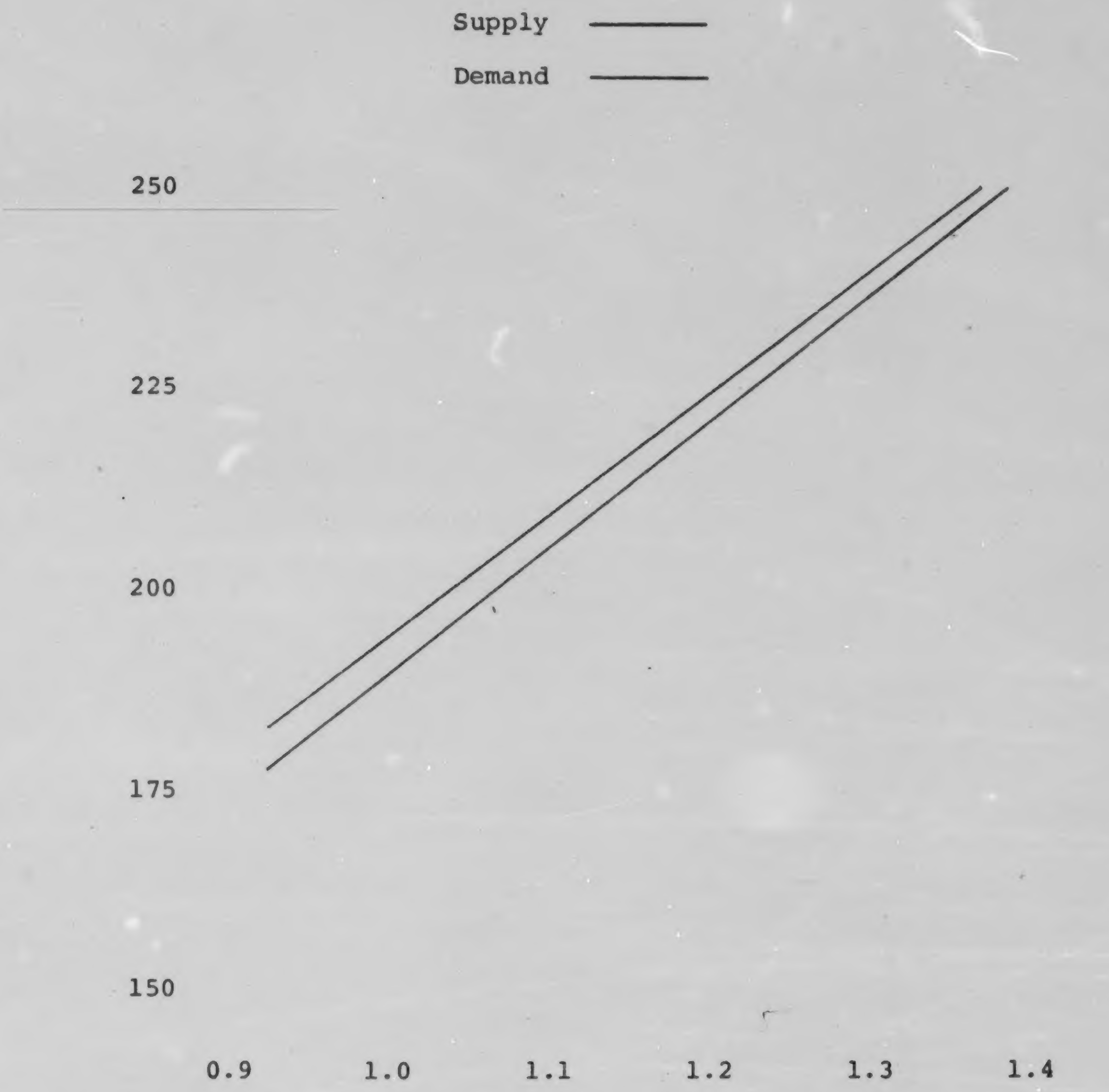
[18] Honolulu Advertiser, March 12, 1975, p. A3.

[19] Planning For Oahu, p. 37.

GRAPH 13

Urban Water Supply and Demand on Oahu Under Directed Growth
(in millions of gallons per day)



Population (in millions)

the following projections for water supply and demand on Oahu:

Population Served by BWS	
1970:	576,633
1975:	699,500
1980:	765,200
1985:	879,500
1990:	984,000
1995:	1,090,000
2000:	1,196,000
2005:	1,298,000
2010:	1,399,000
2015:	1,498,000
2020:	1,600,000[20]

The Second Edition of the 2020 Plan projects the following increase in per capita consumption:

Per Capita Demand on Oahu

(Gallons per person per day)

F.Y.	1971:	190
	1976:	203
	1981:	216
	1986:	226

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[20] Honolulu Board of Water Supply, 2020 Plan: Second Edition (Honolulu: Honolulu Board of Water Supply, January, 1975), p. 106.

1991:	232
1996:	235
2001:	239
2006:	243
2011:	247
2016:	251
2020:	255[21]

Using its population projections and per capita consumption estimates, the Board of Water Supply predicts the following increase in demand for fresh water:

Average Daily Demand

(millions of gallons per day)

F.Y.	1971:	109.75
	1976:	135.7
	1981:	165.6
	1986:	198.3
	1991:	228
	1996:	257
	2001:	286
	2006:	315
	2011:	345
	2016:	376
	2021:	407[22]

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[21] Ibid., p. 108

[22] Ibid., p. 107.

The following table provides a summary of the Board's projections relating to the demand for fresh water on Oahu:

Population Served by BWS

1974:	632,247
2020:	1,600,000

Per Capita Demand

(gallons per day)

1971:	190
2021:	255

Average Daily Demand

(millions of gallons per day)

1974:	121.70
2020:	407

The Board summarizes its supply situation as follows:

Sustainable Capacity

(millions of gallons per day)

Present System:	170.60
Additions to Present System:	146.80
Capacity from Alternate Sources:	96.00
Total Capacity in 2020:	413.40[23]

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[23] Ibid., p. 102 a. Under "Alternate Sources" some of which will be developed by the year 2020, the Board of Water Supply includes the exchange of sewage treatment plant effluent, demineralization of brackish water, development of

A comparison of the original 2020 Plan, published in February, 1971, and the Second Edition, published in January, 1975, reveals certain shortcomings in the original document, and illustrates the uncertainties involved in long range planning.

The original 2020 Plan estimated that the Board would serve a population of 1,420,000 in the year 2020. The Second Edition has revised this estimate upward to 1,600,000.

The original failed to pay adequate attention to changes in per capita consumption. After a close reading of the original 2020 Plan, the writer remains uncertain whether the Board's planners included per capita consumption estimates in their projection of total urban water demand. This situation is corrected in the 1975 revision, and estimates of per capita consumption are clearly included in demand projections.

The 2020 Plan published in 1971 estimated that the Board would have to provide Oahu's water users with an average of 253 mgpd, by the year 2020, an annual increase of approximately 3 mgpd. In the 1975 revision, the Board's planners estimated that the BWS would be called on to supply 407 million gallons of fresh water per day by the year 2020. The revised figure represents an annual increase of approximately 6 mgpd from 1975 to the year 2020. If one accepts

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surface water and the desalination of sea water. All of these alternatives will be discussed in Chapters 6 through 10 of this dissertation.

the 1975 revision of the 2020 Plan as accurate, it is quite clear that the original missed the mark by a wide margin.

As far as supply is concerned, the original 2020 Plan offers the opinion that supply from natural sources will "approximately equal" the average daily demand for water in 2020 without recourse to alternative water sources. The original adds the provision that alternative sources will be developed if demand threatens to overtake supply.[24]

In the opinion of the writer, the Board's 1975 projections are more sophisticated and more accurate than the projections prepared in 1971. However, the situation described in the Second Edition of the 2020 Plan offers some cause for concern. For example, the present supply and demand situation should be compared with the condition projected for 2020:

Sustainable Capacity
(millions of gallons per day)

Present Supply:	170.60
Present Demand: (average day)	121.70
Surplus Capacity:	48.90[25]

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[24] 2020 Plan, p. 18.

[25] It should be noted that on the maximum demand day in 1974, the demand for water actually exceeded the sustainable capacity of the system. Maximum day demand in 1974 was 173.11 million gallons.

Sustainable Capacity

(millions of gallons per day)

Supply in 2020: 413.40

Demand in 2020: 407
(average day)

Surplus Capacity: 6.40[26]

The Board's projections show that the margin of average supply over average demand declines from over 48 mgpd in 1975, to 6.4 mgpd in the year 2020. In the opinion of the writer, effective water resource management and the Board's responsibility to the public demand a wider margin of safety. The margin of safety can be enlarged by making sound public policy decisions to conserve water resources and limit demand. The margin may also be extended by providing additional sources of supply beyond those already contemplated by the 2020 Plan.

A comparison of the Hawaii Water Resources Regional Study projections with those of the City and County (Department of General Planning) and the Board of Water Supply offer another cause for concern. Frequently the projections begin with somewhat different base figures and produce widely differing results. Graph 14, on the following page, for example, indicates that the Board of Water Supply's

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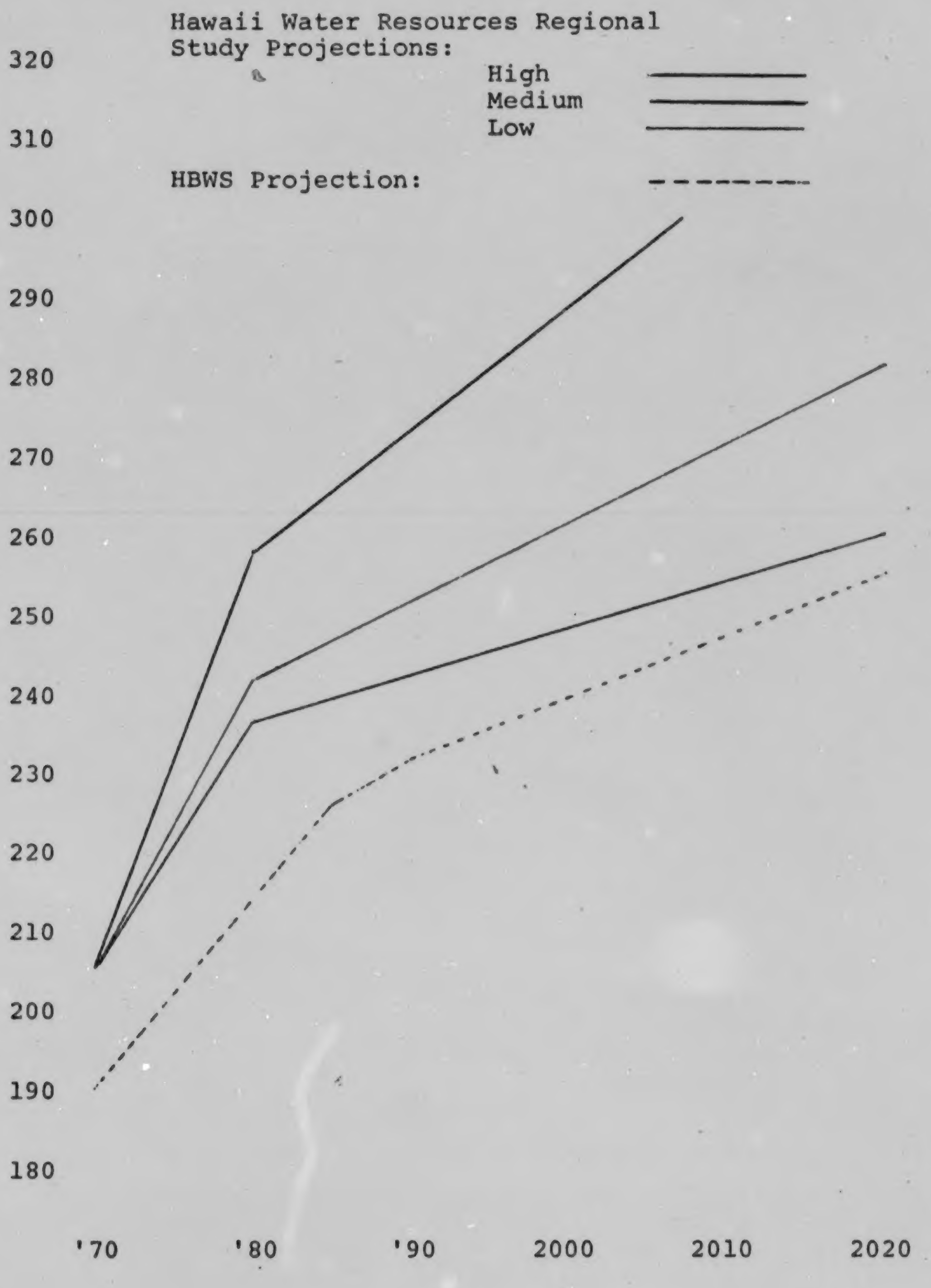
[26] The Board of Water Supply estimates maximum daily demand at 610 mgpd, in 2020. This estimate exceeds sustainable capacity by a wide margin.

GRAPH 14

Per Capita Consumption (in gallons per day)



projections for increases in per capita consumption are more conservative than the lowest estimate made by the Hawaii Water Resources Regional Study. On the other hand, Graphs 15 and 16, on the succeeding pages, show that the Board's population projections and urban demand forecasts lie within the upper and lower ranges predicted by other agencies.

At present, water resource planners in the various agencies are operating under somewhat different definitions of terms and assumptions about the future. If the community is to make effective decisions about the allocation of natural resources, energy resources and capital resources, water resource planning efforts will have to be much more closely coordinated than they have been in the past.

In Chapter 6, the writer offers specific recommendations intended to improve communications between the Board of Water Supply and the Departments of both the City and County of Honolulu and the State of Hawaii. In that Chapter, the writer proposes the establishment of a State Environmental Protection Commission to coordinate a broad spectrum of water related activities including water resource planning.

GRAPH 15

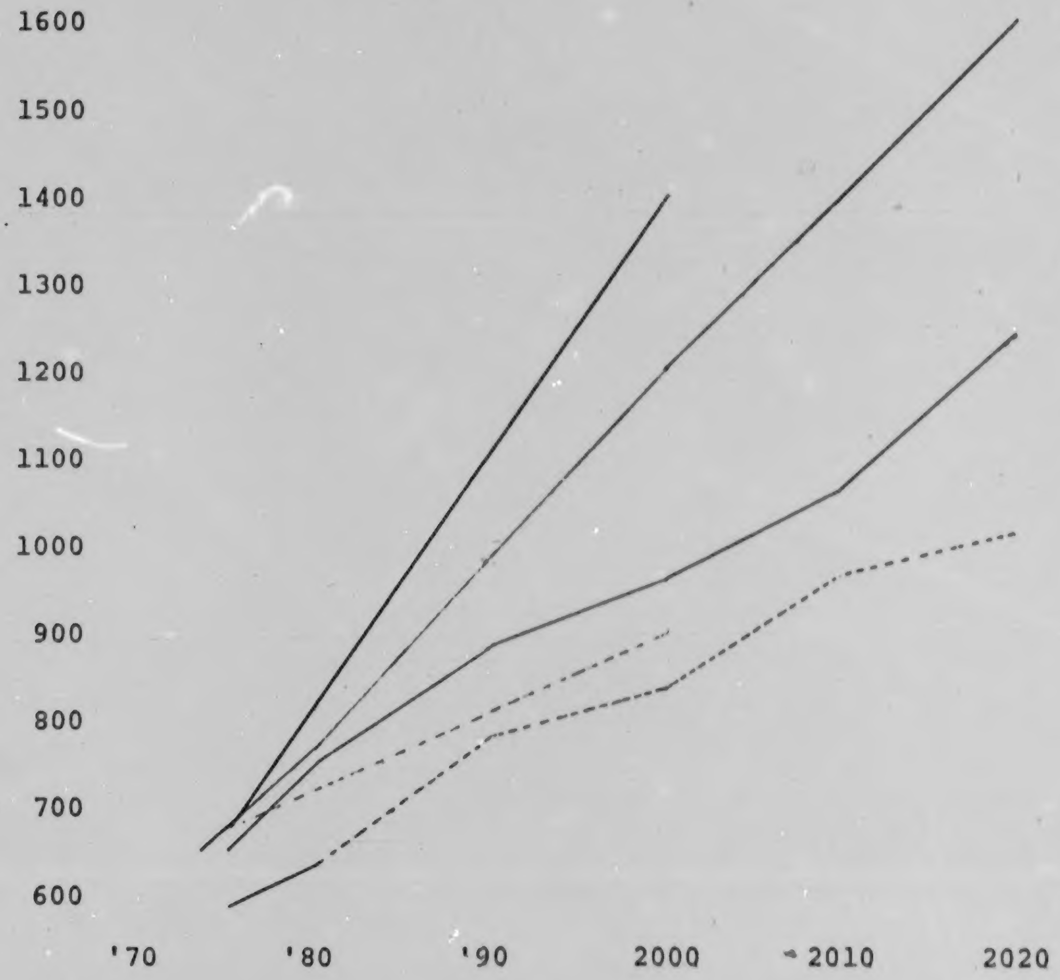
Oahu's Population (in thousands)

City and County Department of
General Planning: High Projection: ————
Low Projection: - - - - - - - -

Board of Water Supply Projection: ————

State Department of Planning and
Economic Development Projection
under the Moderated Growth Option: ————

U.S. Water Resources Council
Projection: -------

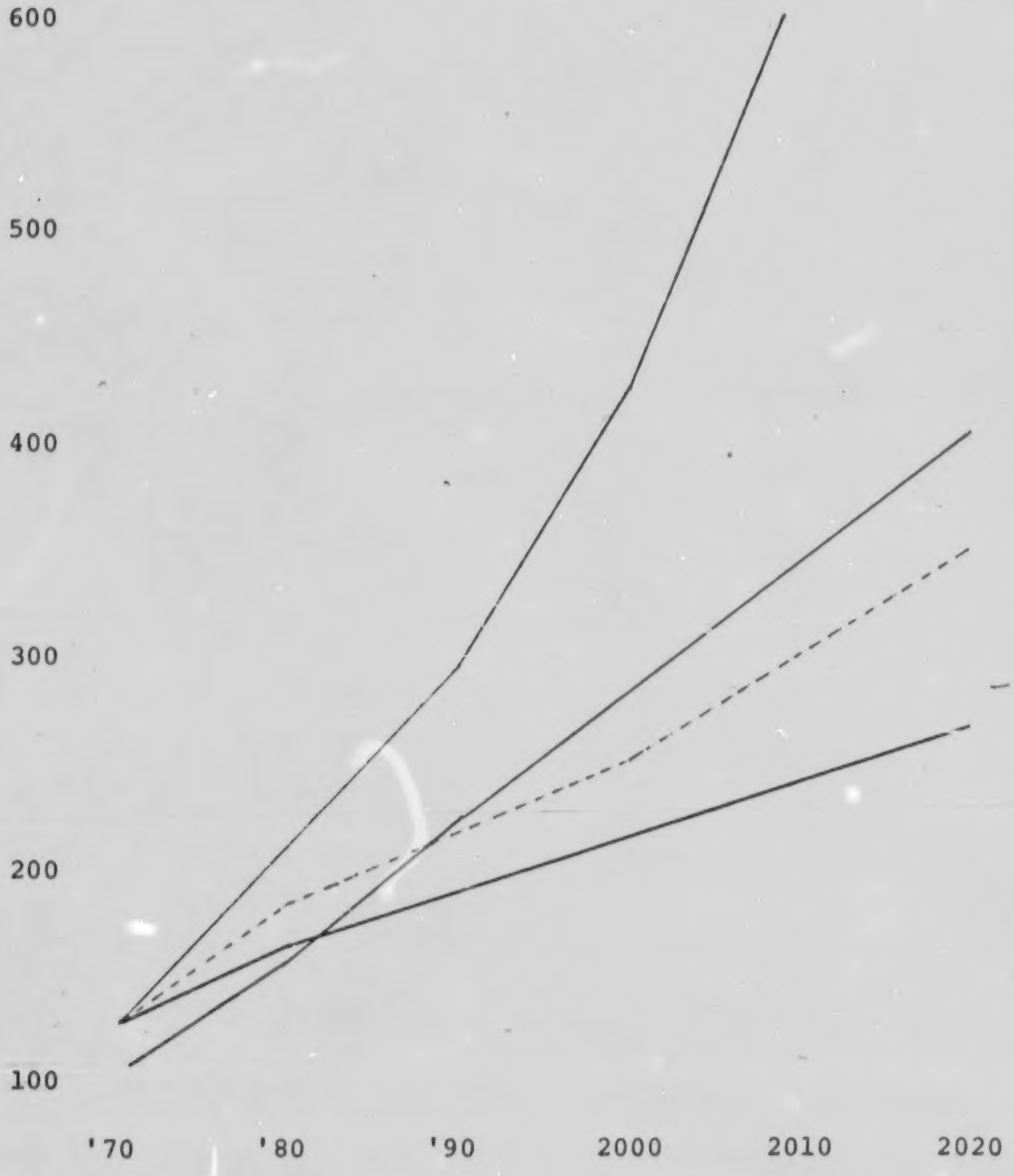


GRAPH 16

Urban Water Demand on Oahu (in millions of gallons per day)

Hawaii Water Resources Regional Study:
High Projection: ————
Medium Projection: - - - - - -
Low Projection: ————

Honolulu Board of Water Supply Projection: ————



Chapter 4

THE MANAGEMENT OF THE BOARD OF WATER SUPPLY

One of the major reasons cited in favor of creating the Board of Water Supply was that a semi-autonomous organizatio[illegible]d perform more efficiently than a City Water Depa[illegible]. For forty-five years, ever since the spirited debate of 1929, most people on Oahu have assumed that the Board was managed in an efficient manner. In fact, although the Board has been effective, it has not been efficient. The Board has provided the people of Oahu with an ample supply of high quality water; and it has performed effectively, but it has not carried out its responsibilities efficiently. The Board's inefficiency has resulted in operating expenses that are a good deal higher than they should be. Moreover, the Board's semi-autonomous status has helped shield it from the scrutiny that could have improved its efficiency.

The Board's computer is a case in point. Since the 1920's and the 1930's, Honolulu's water supply system had increased not only in size, but in complexity. During the 1960's it became clear that the Board should utilize computer technology in order to deal effectively with increasingly sophisticated problems. Everyone concerned agreed on the desirability of computerization. But there was a great deal of controversy involved in deciding whether the Board should have a computer of its own, or share the data processing facilities of the City and County Department of Information Systems. Two strong personalities became embroiled on opposite sides of the issue.

Manager and Chief Engineer, George Yuen, advised the Board to purchase a computer for its exclusive use. Mr. Yuen saw the computer as a key element in the continued development of an integrated, Island-wide water supply system. George Yuen, like his predecessors, Frederick Ohrt and Edward Morgan, was a determined advocate of maintaining the Board's semi-autonomous status. Although Mr. Yuen made no public statements to the effect that he saw the purchase of a computer for the Board's exclusive use as a means of assuring the Board's continued independence from the City administration, it is fair to assume that the Chief Engineer had this factor very much in mind during the controversy with the City.

Mayor Frank F. Fasi, a forceful advocate of government cost reduction, took up the cudgels for having all City agencies make use of the services of the City's central data processing department. The Mayor knew, as a former State Legislator, that with the advent of computerization in government, many large agencies throughout the nation had moved quickly to acquire their own computers. This phenomenon in state and municipal government in the 1960's was known as "beating the centralization schedules," and whenever it occurs there is considerable added cost to the taxpayers. Most often, the additional and largely unnecessary expense occurs outside of public cognizance.[1] Mayor Fasi was convinced that the public interest required the placing of cost effectiveness throughout the City government ahead of the desires of any particular agency for an exclusive-use data processing system.

In July, 1968, while Neal Blaisdell was Mayor of Honolulu, the City was in the process of establishing its data processing center. At that time, the City offered to perform the Board's commercial data processing functions. The offer was tendered in general terms, and it lacked the details necessary for the Board to make a meaningful decision about how to meet its computerization needs.[2]

In May, 1969, the firm of R. W. Beck and Associates, which had worked closely with the Board on several projects dating back to at least 1963,[3] submitted a draft report of a study authorized by the Board and entitled, Data Acquisition and Supervisory Control System.

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[1] Interview with Leo Pritchard, former Executive Assistant to the Mayor, City and County of Honolulu, February 1, 1975.

[2] Honolulu Board of Water Supply, "Background on Award of Multipurpose Computer System Contract," approximate date: June 1, 1973, pp. 1, 2. (Mimeographed.)

[3] Honolulu Board of Water Supply, Contingency Fund Expenditures: 10/62-9/67. The pages of this report are not numbered. The entire report is relevant.

The study proposed the development of a centralized data acquisition and supervisory control headquarters at the Beretania Street Pumping Station.[4] In the 1969 study, R. W. Beck quoted from its own Annual Report on Board of Water Supply Systems for Fiscal Year Ending June 30, 1965, as follows:

> Because of the characteristics of the Honolulu system we believe that considerable savings in operating costs can be realized through centralized control and coordinated operation of all sources serving the Honolulu area. We recommend that telemetering and control equipment be installed which would allow the coordination and operation of primary sources serving the Honolulu area from a central location. . . .[5]

To put the matter briefly, the elaborate, 11 section report submitted in 1969 simply confirmed the expectations R. W. Beck had held for the Board of Water Supply in 1965.

In the "Alternative Systems" section of the report, R. W. Beck described three basic computerization plans that the Board might adopt, and several variations of each of these basic options. None of these plans or variations contained any mention of utilizing the facilities of the Department of Information Systems, City and County of Honolulu. In the final section of the report, R. W. Beck provided the Board with a detailed computerization schedule, and estimates of what each stage of development would cost.[6]

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[4] R. W. Beck and Associates, Data Acquisition and Supervisory Control System (Seattle, Washington: R. W. Beck and Associates, October, 1969), Section 2, pp. 1-3.

[5] Ibid., Section 4, p. 4.

In August, 1970, the Department of Information Systems (DIS) offered to perform the Board's accounting, billing and other commercial data processing operations. The proposal was entitled, A Suggested Consolidation Plan for the Board of Water Supply, and its presentation before the Board marked the beginning of intense argument. The consolidation plan projected an annual savings of $88,680 over the then current data processing costs.[7] Beginning in August, 1970, the mass of paper in the form of memoranda, letters and reports became staggering as it "shot" back and forth between the Fasi Administration and the Board of Water Supply.[8]

An important consideration in the controversy was whether the Department of Information Systems had the capability to perform the Board's data processing work. The following is an evaluation of the Department of Information Systems prepared by the Board of Water Supply:

> DIS currently has an IBM 360/50 system and an IBM 360/40 system, both highly sophisticated third generation computer systems. The complement of

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[6] Ibid., Sections 8 and 11.

[7] Department of Information Systems, City and County of Honolulu, A Suggested Consolidation Plan for the Board of Water Supply (Honolulu, Hawaii: Department of Information Systems, August, 1970). The pages of this report are not numbered. The entire report is relevant.

[8] Leo Pritchard, interview, February 1, 1975.

personnel is approximately 72 employees. DIS, which is housed in the City Bank Building in downtown Honolulu, currently performs various data processing functions for several City agencies. DIS undoubtedly has the facilities necessary to process the applications now performed by the Board's in-house unit (a leased data processing unit) and is able to absorb additional work loads.[9]

In October, 1970, the Board of Water Supply staff released its rebuttal to the DIS proposal. The staff began its reply as follows:

1. There would be no savings in operating costs to the BWS from the proposed consolidation, and in fact, the operating costs after consolidation would exceed current BWS operating costs.
2. It would cost BWS conservatively, $14,832 more over the first five years or an average of nearly $3,000 annually under consolidation, thereby making such an undertaking economically unsound.
3. The advantages of close control, coordination and responsiveness inherent in an in-house operation would be lost under consolidation. This will tend to reduce the BWS's effective programs and reduce its ability to meet the changing and increasing demands for reliability, quality and economy of service to its customers.
4. Consolidation would tend to inhibit full exploitation and development by the BWS of modern computer technology and would be detrimental to BWS long-range program for monitoring and automatic control of the system.

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[9] Honolulu Board of Water Supply, Report on Proposed Consolidation of Board of Water Supply Data Processing Operations with the Department of Information Systems (Honolulu, Hawaii: Honolulu Board of Water Supply, October 22, 1970), p. 9.

> In summary, there appears to be no benefit or advantage to the proposed consolidation, economically or otherwise.
>
> Recommendation
>
> On the basis of the foregoing conclusions, we recommend that the department's data processing and computer functions remain under the control and direction of the BWS.[10]

Although the Board's staff concluded that consolidation with DIS would bring no savings, members of the City Administration believed that the in-house advantages of an exclusive-use computer were the staff's primary considerations. Convenience was one consideration. Of course it would be more convenient for the staff to have a computer on the premises at Beretania Street than to have to communicate with the DIS facility in downtown Honolulu. But the DIS proposal called for the installation of a satellite computer system at Beretania Street; the satellite system would be fully integrated with the central data processing units downtown, and the communications problem would be minimized. George Yuen's vision of Oahu's future water supply system was unquestionably another factor in the staff's position. The following statement appears over Mr. Yuen's signature in his message to the Chairman and Members of the Board of Water Supply in the 1970 Annual Report:

> Looking ahead it is possible to envision all of Oahu encircled by pipelines, the recycling of waste water for irrigation and industrial use, nuclear power plants for the desalting of sea water, the operation of the water system under computerized and centralized

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[10] Ibid., pp. 3, 4.

control for maximum efficiency, and the recovery of surface water for domestic use.[11]

From the perspective of City officials, there appeared to be no room in this conception for sharing computer time with other agencies, even though such cooperation would mean considerable savings to Oahu's water customers. City officials had the impression that the Board and its staff were refusing to consider the DIS proposal because they saw it as a potential threat, the beginning of the erosion of the Board's autonomy. What began as a businesslike management proposal by one agency, turned into a struggle on the part of another agency to defend against a perceived threat to its status.[12]

In April, 1971, R. W. Beck presented another report on the Board's computer requirements, and recommended a multi-purpose computer system to fulfill three functions:

1. Commercial data processing.
2. Engineering and scientific data processing (this function would be essentially a research tool using information gathered from the operation of the pumping and distribution system to design mathematical models for water system simulation).
3. Automatic control (computerized control of electrical power to the various points of the pumping and distribution system based on the

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[11] Honolulu Board of Water Supply, 1970 Annual Report, p. 6.

[12] Leo Pritchard, interview, February 1, 1975.

> telemetric feedback of information to the centralized data processing unit).[13]

This preliminary report blossomed into a monumental work entitled, Engineering Study and Analysis: Computer System for Automatic Control and Commercial and Engineering Data Processing, which R. W. Beck presented to the Board in February, 1972. Mr. Beck's 1972 report made two key points: first, that a multi-purpose computer with the three capabilities described above would be necessary to meet the Board's requirements, and second, that the DIS data processing facilities could not possibly meet the Board's needs for a multi-purpose computer. These needs could be met only by an in-house computer for the Board's exclusive use.[14]

R. W. Beck's multi-purpose computer proposal caused consternation among members of the Fasi Administration. City officials recalled that the commercial data processing function had been the only function considered during several years of negotiations on the computer question. No one had disputed the Department of Information Systems' ability to carry out commercial data processing operations for the Board. Then in February, 1972, R. W. Beck not only publicized new "requirements" for the Board, but had specifically discounted any role for DIS. To City officials, it looked like R. W. Beck and the Board of Water Supply had found another way to "skin the cat."[15]

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[13] Honolulu Board of Water Supply, "Background on Award of Multipurpose Computer System Contract," pp. 1-3.

[14] R. W. Beck and Associates, Engineering Study and Analysis: Computer System for Automatic Control and Commercial and Engineering Data Processing (Seattle, Washington: R. W. Beck and Associates, February, 1974), Sections 2 and 9.

On June 29, 1972, the Board met to consider R. W. Beck's most recent proposals. The five members of the Board who were present,[16] agreed that the Board should have a multi-purpose computer for its exclusive use as recommended by R. W. Beck. The members also agreed that before taking final action, the Chairman and the Manager and Chief Engineer would pay a courtesy call upon the Mayor and inform him of the impending decision. The following day, Messrs. Rotz and Yuen visited Mayor Fasi. An emotionally charged discussion took place on the computer issue, and no agreement was reached on any substantive matters. It was agreed, however, that Gerald Mann, Director of the Department of Information Systems, and Leo G. Pritchard, the Mayor's Executive Assistant, would meet with members of the Board's staff to discuss the issue in detail.

Subsequently, Messrs. Pritchard and Mann spent an afternoon discussing the computer question with members of the BWS staff. Again, neither side changed its position.

On July 3, 1972, the Board met at the Sheraton Waikiki to discuss the computer situation. Chairman Rotz informed the Board about the June 30 meeting with the Mayor, and the subsequent meeting between representatives of the City Administration and BWS staff members. The majority of the members decided in favor of writing a letter to the Mayor suggesting a meeting between representatives of DIS, the BWS and R. W. Beck.[17]

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[15] Leo Pritchard, interview, February 1, 1974.

[16] Board members, Edward Y. Hirata and Stanley S. Takahashi were absent from this meeting.

The letter informed the Mayor that the meeting would have to take place no later than July 13, because the Board intended to take definite action at its July 17 meeting. City Hall undoubtedly saw this latest communication from the Board as an ultimatum. The record does not indicate what response, if any, the City made to the letter.[18]

On July 17, 1972, the Board met to take action on R. W. Beck's proposals. Gerald Mann attended the meeting and asked the Board to postpone any final decision on the computer question. Mann requested a two or three month delay in order to permit DIS to carry out studies of water system models developed by R. W. Beck. Beck's recommendations involved a capital expenditure on the order of $600,000 and Mann wanted an opportunity to determine the accuracy of certain techniques that R. W. Beck had proposed for the Board's data processing operation. It is also fair to assume that Mann wanted more time to evaluate his Department's ability to meet the Board's new requirements. But after listening to Mann's request, the Board decided that further delay would be pointless. By unanimous vote, the Board approved the multi-purpose computer system as recommended by R. W. Beck.[19]

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[17] The Minutes of the July 3, 1972, meeting of the Board of Water Supply show that only Member George Apduhan opposed this course of action. All six of the other members concurred.

[18] Honolulu Board of Water Supply, Minutes of the Meetings of the Board of Water Supply, July 29, 1972, and July 3, 1972.

In all fairness to the members of the Board, the writer must conclude that the Board acted in good faith when it made the decision that it did. The entire issue had become so emotionally charged that it was difficult to arrive at an effective management decision. Moreover, a good deal of the responsibility for the emotionalism involved in the issue belongs to the Department of Information Systems. Department representatives were so convinced of the correctness of their position that their presentation to the Board on July 17 struck the members as more emotional than rational. Board Member Edward Hirata recognized that, given the strong feeling on both sides of the issue, it would be better to delay the final decision on the Board's data processing needs. Mr. Hirata moved for a postponement during the July 17 meeting, but his motion died for lack of a second. Manager and Chief Engineer, George Yuen, attended the July 17 meeting and reminded the members that further delay would cause the Board additional expense, and that the Board should proceed with the acquisition of a multi-purpose computer in order to carry out its functions properly.[20]

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[19] Robert H. Rotz, letter from the Chairman of the Board of Water Supply to Frank F. Fasi, Mayor of the City and County of Honolulu, July 20, 1972. The Minutes of the July 17 meeting show that the decision to acquire the multi-purpose computer was made by a 6-0 vote, with Member Stanley S. Takahashi absent.

The Board's decision seemed abrupt and ill-advised to City officials. Mayor Fasi wrote a lengthy letter to the Board in which he reviewed the history of the computer issue and refuted the evidence R. W. Beck had offered in support of its recommendations. The following paragraphs from the Mayor's letter reveal the Mayor's concern about the Board's decision:

> My Executive Assistant has indicated that Beck seems to establish long-term relationships with their clients for maintenance purposes. Frankly, I am suspicious of their role in this project. It appears to me that the public will have to pay their fees in perpetuity.
>
> I also question your own "unbiased" evaluation. You have accepted only Beck's statements regarding the DIS proposal. Beck clearly has a vested interest in implementation of its own proposal. DIS could not possibly receive a fair evaluation since acceptance of the DIS approach by Beck would be an admission of gross error on their part.
>
> I recognize and respect the autonomy of the Board. However, as Mayor of the City and County of Honolulu, and with the best interest of the public in mind I have no recourse but to insist that the Board take the following steps:
>
> 1. Reverse the decision regarding approval of the multi-purpose computer recommended by Beck.

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[20] Minutes of the Meeting of July 17, 1972; telephone conversation of February 24, 1975, with Manager and Chief Engineer, Edward Hirata, on the subject of the July 17, 1972, meeting.

2. Direct Beck not to proceed with the preparation of bid specifications or any other action until this issue has been positively resolved.

3. Grant DIS its request to continue their investigation for 60 to 90 days. . . .[21]

Perhaps the most objective view of the computer issue was a review of the entire controversy by two data processing experts employed by the Federal Government and stationed at Pearl Harbor. After carefully considering the Board's needs and the Department of Information Systems' abilities, the two Federal experts announced their support for the DIS position.[22] But the Board dismissed their findings as inadequate.

The next substantive action took place in May, 1973, when George Yuen reported to the Board on bids that had been received for furnishing the multi-purpose computer, and recommended that the Board appropriate $600,000 for the project.[23] The Board approved the actions of the Manager and Chief Engineer and appropriated the amount requested from the Bond Fund.

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[21] Frank F. Fasi, letter from the Mayor of the City and County of Honolulu to Mr. Robert H. Rotz, Chairman of the Board of Water Supply, August 2, 1972. The Board's written reply to the Mayor was courteous, but negative.

[22] Leo Pritchard, interview, February 1, 1974.

[23] George Yuen, letter to the Members of the Board of Water Supply, May 31, 1973.

In November, 1974, the staff of the Board of Water Supply prepared a financial report entitled, Comparison of Expenditures: Beck's Projection Vs. Action For Fiscal 1971 Through 1975. Under the heading: "Telemetering Data Acquisition and Control Installation and Equipment," the report stated that Beck's expenditure projection was $645,000. However, the actual expenditure was revealed to be $1,824,000. Thus, R. W. Beck's computer-related proposals produced a cost over-run of $1,179,000.[24]

Cost over-runs are common during inflationary periods; but an over-run of $1,179,000 on an estimate of $645,000 is a cause for serious concern. In retrospect, the fear expressed by the BWS staff in October, 1970, that the use of the DIS computer would cost the Board an extra $3,000 per year, appears to be absurd. Rather than refuse cooperation with DIS, the Board should have made every effort to establish common ground and promote a harmonious working relationship with the City's data processing agency. Decisions that lead to $1,179,000 over-runs are decisions that mortgage the future. In 1975, the writer, as Chairman of the Board of Water Supply, will have to appear before the public and justify an increase in water rates knowing that at least part of that increase should not have been necessary.

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[24] Honolulu Board of Water Supply, Comparison of Expenditures: Beck's Projection Vs. Actual For Fiscal 1974 Through 1975 (Honolulu, Hawaii: Honolulu Board of Water Supply, November 6, 1974). The report contains two pages. (Mimeographed.)

In the final analysis, no individuals are responsible for the computer cost over-run. The problem is an institutional one. The quality of the Board's decision making was low in this particular instance because the Board was not accountable to the public. The Board acted as its own final authority. In Chapter 6 of this dissertation, the writer offers several proposals to modify the present status of the Board and to increase its accountability to the public.

As far as the computer itself is concerned, the Board is moving ahead with the implementation schedule recommended by R. W. Beck.[25] Since the Board has been committed to the acquisition of the multi-purpose computer since May, 1973, the best that can be done is to use the system as effectively as possible. The writer has received assurances from Barry M. Suyemoto, Waterworks Controller, that the Board will be able to provide computer facilities to the City and County after certain commitments to R. W. Beck are met, and after the Board's staff is thoroughly trained in the operation of the computer. The Board should be able to provide data processing facilities to other agencies early in 1976.

Traditionally, the members of the Board have cooperated closely with the Manager and Chief Engineer. The

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[25] Stuart M. Alexander, "Multipurpose Computer for the Honolulu Board of Water Supply," paper presented to the Fall Conference of the California Section, American Water Works Association, Honolulu, Hawaii, October, 1974.

Manager presents the Board with alternatives and recommendations on various courses of action, and although the Board has specific administrative and executive functions, the members have generally accepted the advice of the Manager. In October, 1973, shortly after the Board committed itself to the acquisition of the multi-purpose computer, Manager and Chief Engineer, George Yuen, submitted a report to the Board members entitled, "Powers, Duties and Functions of the Board and Manager and Chief Engineer." In the report, the BWS staff developed the idea that the Board is primarily a policy making body, that it is neither an administrative nor an executive entity, and that administrative responsibilities are assigned to the Manager and Chief Engineer.[26] The report was submitted to the Corporation Counsel (the City's attorney) for review and comment. The Corporation Counsel refuted the Manager's contentions, and based upon an examination of the 1972 City Charter, reconfirmed the Board's executive functions.[27]

Ever since his appointment to the Board in January, 1973, the writer has maintained that the members of the Board should provide strong executive leadership for the BWS. The water resource and water supply challenges of the present and the future require an activist Board. The merger of the Sewers Division with the Board of Water Supply provided a major opportunity for the members of the Board to demonstrate their leadership. The transfer of the Sewers Division had been mandated by the 1972 election, and it was scheduled to go into effect in January, 1974.[28]

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[26] Honolulu Board of Water Supply, "Powers, Duties and Functions of the Board and Manager and Chief Engineer," Honolulu, Hawaii: Honolulu Board of Water Supply, October, 1973. (Mimeographed.)

[27] Leo Pritchard, interview, February 1, 1975.

In preparation for the merger, the writer, as Chairman of the Board of Water Supply, presented a paper entitled, "Reorganization of the Board of Water Supply," in November, 1973. The writer made the following points:

1. The merger of sewer and water operations is a significant change requiring a comprehensive administrative and organizational response. Over 400 sewer employees would be involved in the merger; it would not be a simple matter of absorbing an incidental function into the BWS.
2. Water supply and sewer operations constitute two large, complex and distinct systems. There is little reason to set one agency above the other. Therefore the re-organization of the Board should establish the equal status of Water Affairs and Sewer Affairs in the organizational structure.
3. Reorganization causes serious consequences of a personal nature for some employees, and difficult choices for others. Yet there is an over-riding need to serve the best interests of the people of the City and County of Honolulu.[29]

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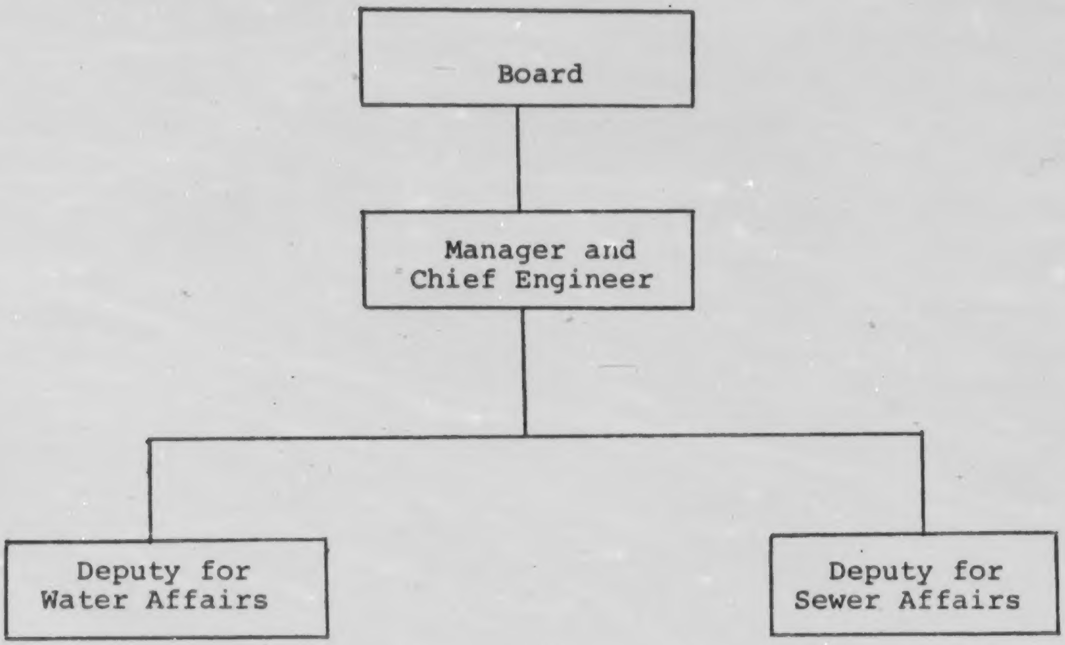
[28] Edward Y. Hirata, "Honolulu's Water and Sewers: An Unfinished Case History," paper presented to the Fall Conference of the California Section, American Water Works Association, Honolulu, Hawaii, October, 1974.

[29] John Henry Felix, "Reorganization of the Board of Water Supply," November, 1973.

Basically, the Board of Water Supply would be reorganized as follows:


Board
Manager and Chief Engineer
Deputy for Water Affairs
Deputy for Sewer Affairs

The Board approved the reorganization in March, 1974, by a five to one vote, and appointed Mr. Edward Hirata, the Manager and Chief Engineer, of the newly expanded agency. Mr. Hirata came to the BWS from the City where he served as City Engineer and Director of Public Works. As Director of Public Works, Mr. Hirata had supervised the operation of several agencies including the Division of Sewers. Mr. Hirata also served as an ex-officio member of the Board of Water Supply. The members of the Board found Mr. Hirata eminently qualified by training and experience to lead the Board in its combined water-sewer operations. Mr. George Yuen became the Deputy Manager of Water Affairs.

Intense controversy surrounded the reorganization. The press gave prominent attention to a remark by Robert H. Rotz (the member of the Board who cast the lone dissenting vote in the reorganization matter) that the reorganization was a "power play" directed by Mayor Fasi and carried out by the writer. Mr. Rotz claimed to have received a telephone call threatening him with violence if he spoke with reporters about the reorganization, and at one point a "bare-chested stranger" allegedly appeared at the back door of Mr. Rotz' home. The police investigated these claims, and found nothing to substantiate them. The controversy was orchestrated by the press.

The conduct of the Honolulu Advertiser, in particular, took place within a larger context: the Advertiser's long-standing and bitter feud with Mayor Fasi and the City Administration. The year 1974 was an election year. Mayor Fasi was expected to be a candidate for the Office of Governor of the State of Hawaii, and the Advertiser was determined to embarrass him whenever possible. The Advertiser's editors printed some exceptionally biased and vicious material including a letter accusing the writer of being a "hatchet man." The truth is that the writer acted independently throughout the reorganization matter and especially with regard to the personnel changes involved in the reorganization. The writer believed, and believes today, that he acted in the best interests of the Board and the people of Oahu.

The writer decided to try to clear the air of innuendo and accusation and restore a rational climate of discussion. The writer called a special meeting of the Board for April 10, 1974, and invited all of the concerned individuals, including the media, to a discussion of the institutional history of the Board, its semi-autonomous status and the reorganization then in process. A University of Hawaii faculty member and two former members of the City Charter Commission (one of them also a faculty member) spoke on the issues at hand.[30]

Although the Board continued its normal operations and proceeded with reorganization, the press continued a drumfire of criticism until the Primary Election on October 5, 1974. Mayor Fasi was defeated in his bid for the Governorship in that election, and the press rapidly lost interest in the reorganization issue. On September 17, 1974, less than three weeks before the election, the Advertiser printed a bitter denunciation of the reorganization written by Robert Rotz. Although the writer prepared a rebuttal entitled, "Water Board's Responsibility to the Public," and submitted it to the Advertiser within ten days of the Rotz article, the Advertiser withheld the writer's reply from print until October 16, when it could no longer have any effect on the outcome of the Primary Election.[31]

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[30] Robert Dodge, comments on the City Charter Commission's considerations of the semi-autonomous status of the Board of Water Supply; Peter F. Senecal, "The Water Crisis of the 1920's and the Origins of the Board of Water Supply"; Daniel Tuttle, comments on the Board's semi-autonomous status and the reorganization, April 10, 1974.

In June, 1974, the Board and its Manager became interested in bringing in an independent management consultant to evaluate the agency and to recommend improvements in the Board's organizational structure and daily operations. Discussions with the firm of Management Resources Consultants, Inc. (MRC), led to the Board's decision to authorize the firm to perform a preliminary management survey. On September 12, 1974, the principal consultant, Mr. Leo C. Pritchard, submitted MRC's report to Mr. Hirata. Mr. Pritchard set the tone of the report in the Introduction by writing:

> From a standpoint of even moderate degrees of management sophistication, it is seen that while the Board's service to the consumer is excellently effective, it is performed with less than a high degree of efficiency and the cost is high. Of concern is the high cost of operations as it relates to the effectiveness of service to consumers and how such cost becomes reflected in future water rates.[32]

The MRC study made the following points:

1. The organization plan adopted in March 1974, should receive extensive examination and adjustment.

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[31] Robert H. Rotz, "Placing Water Board Under City Control Opposed," Honolulu Advertiser, September 17, 1974, p. A11; John Henry Felix, "Water Board's Responsibility to the Public," Honolulu Advertiser, October 16, 1974, p. A17.

[32] Leo C. Pritchard, Report of Preliminary Management Survey (Honolulu, Hawaii: Mangement Resources Consultants, Inc., September 12, 1974), p. iii. Mr. Pritchard resigned his position as Deputy Managing Director of the City and County of Honolulu in May, 1973, in order to join MRC as a management consultant.

2. There is very little relationship between the goals and objectives of the BWS, and its formal organizational structure.

3. The Board has no Master Water Policy. A good deal of work will be necessary to develop one. At present, there is no way of monitoring progress toward the fulfillment of organizational goals.

4. The following is a summary of management problems that exist within the Board of Water Supply:

    a. Organization levels of supervision are excessive and costly. Good management practice generally requires the existence of no more than five supervisory levels between a worker and the top manager. But in the Board's Operations Division, for example, there are eleven levels between Pipefitters and the Manager and Chief Engineer.

    b. There is little effective control of work orders.

    c. Supply functions are carried out in a costly and insecure manner. One example of insecurity is the theft of approximately $100,000 worth of water meters from a Board facility in 1973. Under the present circumstances the Board suffers many thousands of dollars in losses, due to pilferage every year.

    d. Work crews waste a great deal of time going to and from job sites. Much of this lost time could be prevented by more effective scheduling.

    e. Overtime costs are excessively high. There are several specific reasons for this, and the situation could be corrected by taking effective management action.

    f. Due to the inadequacy of the supply function, there are an excessive number of shopping errands for the purchase of parts and material.

    g. The lines of distinction of tasks and functions are too finely drawn. The result is that special personnel are required to perform functions that personnel already in the field could perform. This is a supervising and dispatching problem.

h. The job of management improvement is not structured highly enough to be meaningful. There is a real need to provide the Manager and Chief Engineer with specialists trained in management analysis and improvement.

i. Employees seem to be too deeply involved in paper work. Much of this effort seems to be ineffective.

j. The Investigation Section of the Water Sales and Service Division is falling farther and farther behind in completing its work.

k. Although the Board's service is excellent from the customer's point of view, service effectiveness is excessive in terms of the costs involved in providing services. Thus, the Board carried out its functions effectively, but not efficiently. It is clear that certain management disciplines have been neglected at the BWS over a long period of time.[33]

The BWS staff's reaction to the findings of the preliminary management survey were generally negative. The staff concurred on certain points, and pointed to affirmative action already being taken to ameliorate some of the problems highlighted by the MRC study. But on the whole, the staff's ten page reply to MRC's findings attempted to divert criticism by taking a "MRC doesn't understand how we do things around here" attitude. In certain cases, the staff seemed to intentionally exaggerate and/or misstate some of MRC's findings. Then, having set up a "straw man," the staff would proceed to "demolish" it. All in all, the staff's reply was a fairly crude and entirely unsuccessful attempt to discredit the Preliminary Management Survey.[34]

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[33] Ibid., especially p. 9-10. The original report is paraphrased here.

As to MRC's most important general observation, that although the Board provides effective service, it does so inefficiently and at high cost, the staff replied as follows:

> It has not been shown that service is being performed at 'fairly low efficiency.' The determining factor is whether the customer is willing to pay for a certain quality of service or whether he is willing to forego good service in favor of cost savings. Up to now, our consumers are generally satisfied with the service we are giving them.[35]

On October 17, 1974, Mr. Pritchard appeared before the City Council to describe the findings and recommendations of the MRC report. In that discussion he articulated the differences between effectiveness and efficiency, and openly criticized the inefficiency he found at the Board of Water Supply. In addition to describing the specific management problems listed in subsections a. through k. above, Mr. Pritchard took exception to the BWS staff's attitude with regard to the public's willingness to pay for the Board's services. Mr. Pritchard advised the City Council that the water consumer has no way of knowing whether the Board's services are being performed efficiently, and he has no way of knowing how inefficiencies might be reflected in his water bill. In the case of a semi-autonomous municipal utility like the Board of Water Supply, the consumer is practically at the mercy of the Board's management. If the Board is operated effectively and efficiently, there is no problem. But in a situation where the staff is reluctant to change long established attitudes and habits, the individual water consumer has very little recourse.[36]

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[34] Leo Pritchard, "Management Resources Consultants, Inc. Response to Selected Comments Prepared by Certain Staff Members of the BWS" (Honolulu, Hawaii: Management Resources Consultants, Inc., September 25, 1974). The entire report is relevant. (Mimeographed.)

[35] George Yuen, et al., "Review and Comments on Preliminary Mangement Survey of the Board of Water Supply" (Honolulu, Hawaii: Honolulu Board of Water Supply, September 23, 1974). The entire report is relevant. (Mimeographed.)

In the Preliminary Management Survey, Mr. Pritchard recommended further study on three specific topics:

1. To determine the feasibility of organizing the Board into Management Districts.
2. To determine whether the BWS should establish a Supply Division.
3. To make conclusions and specific recommendations with respect to the Board's work order system.

The Board approved a contract with Mr. Pritchard to carry out a detailed study of these three topics, with special emphasis on the feasibility of organizing the Board into Management Districts. On January 21, 1974, Mr. Pritchard completed and submitted this study entitled, A

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[36] Honolulu Advertiser, October 18, 1974, p. A10; Leo Pritchard, interview, February 1, 1975.

Report of Districting Feasibility. In the Preface of the Report, Mr. Pritchard anticipated that there would be significant opposition from members of the staff to his districting proposals:

> The consulting work has been performed with a genuine and professional spirit of seeking improvements. Changes for the sake of changes are not parts of this report.
>
> It is believed that study of this report in the same spirit can be greatly beneficial to the total body of consumers and to the entire staff of the Board of Water Supply.
>
> It is earnestly hoped that deep entrenchments and personal considerations will not interfere with complete and objective analysis of the proposals contained in the report.[37]

The writer accepts Mr. Pritchard's implicit suggestion that the most important management problem facing the Board is the reluctance of the staff to respond to potential problems and to take advantage of new opportunities in Oahu's water resources and water supply situation:

> Recommended changes, generally, will never be as easily understood or accepted by most people who are affected as they are by the people who suggest them. It is recognized that reluctance and resistance to change is natural and just as deeply entrenched as the problems and conditions recommended for change. To not be aware of the phenomenon is to court rejection of ideas which are very worthwhile and truly needed.
>
> With these realizations, the recommendations for Districting have been well considered. It is believed that the recommended final organization as shown in this report truly is a meaningful management development, not just an alteration of form.[38]

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[37] Leo C. Pritchard, A Report of Districting Feasibility (Honolulu, Hawaii: Leo C. Pritchard, Management Consultant, January 21, 1975), p. ii.

[38] Ibid., p. iii.

Chart 1 on the following page, shows the basic organizational structure of the Board of Water Supply at the start of the study.

The study recommends the establishment of four Districts and the Management Improvement Office as indicated in Chart 2.

Chart 3 shows how each of the Board's functions would be affected by the Districting Plan.

The Districting Plan calls for the division of the Island of Oahu into four Districts as indicated by Map 7.

One of the most important aspects of the Districting Plan is that it will place operational responsibility for water supply closer to the consumer. Functions that are now performed only at the Board's Public Service Building on Beretania Street will be performed at the four District offices:

1. Wahiawa, Central District.
2. Manana, Leeward District.
3. Heeia, Windward District.
4. Kalihi, Honolulu District.

The Board of Water Supply already has automotive and maintenance facilities at these four locations. The Districting Plan would open these facilities up to the public so that water customers could request the installation of water services, ask for emergency assistance, and pay bills. The District Manager would represent the Board of Water Supply in all of its contacts with the public.

CHART 1

BOARD OF WATER SUPPLY ORGANIZATION AT START OF MANAGEMENT RESOURCES CONSULTANTS STUDY

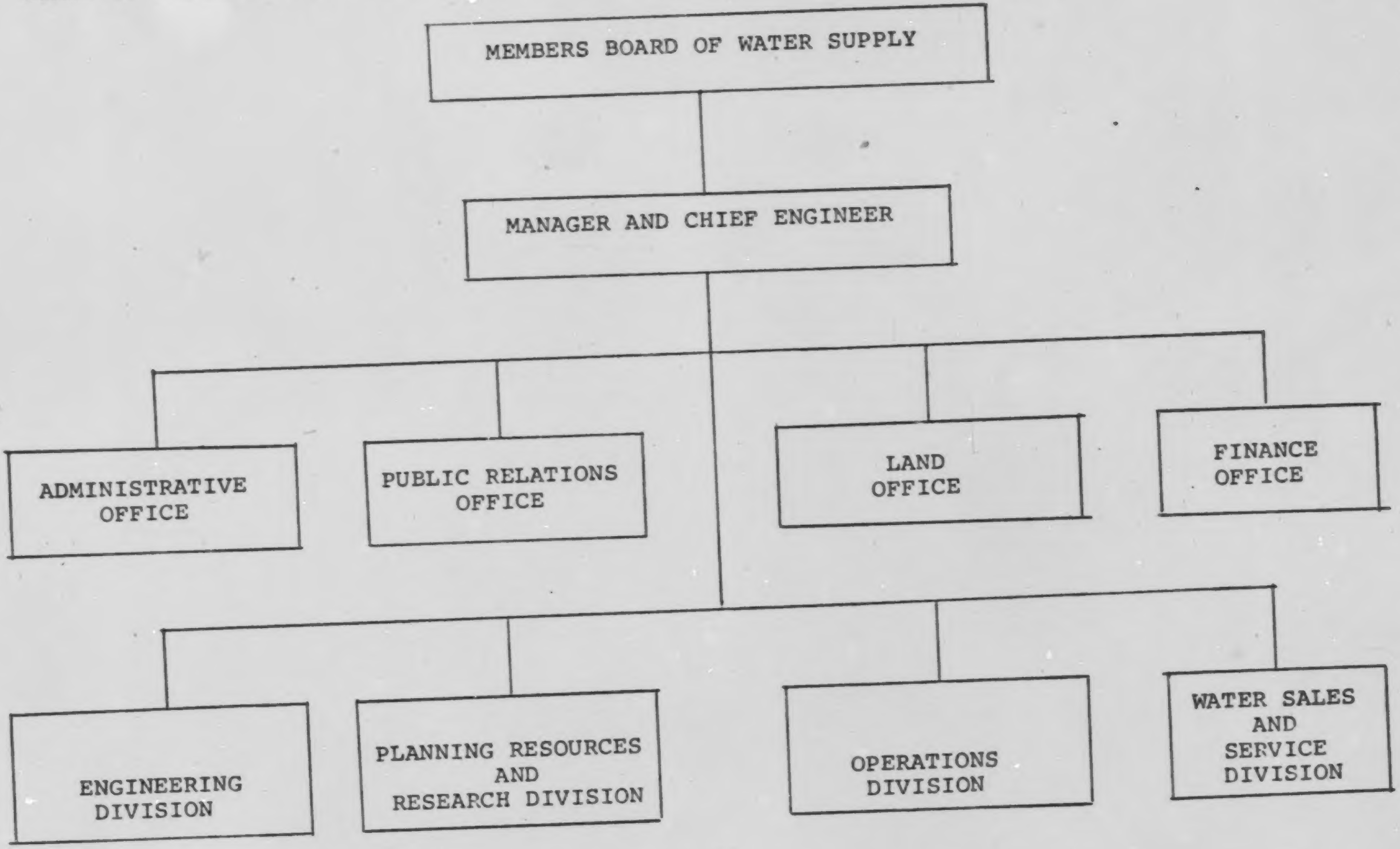

MEMBERS BOARD OF WATER SUPPLY
MANAGER AND CHIEF ENGINEER
ADMINISTRATIVE OFFICE
PUBLIC RELATIONS OFFICE
LAND OFFICE
FINANCE OFFICE
ENGINEERING DIVISION
PLANNING RESOURCES AND RESEARCH DIVISION
OPERATIONS DIVISION
WATER SALES AND SERVICE DIVISION

CHART 2

RECOMMENDED CHANGES IN THE ORGANIZATION OF THE BOARD OF WATER SUPPLY

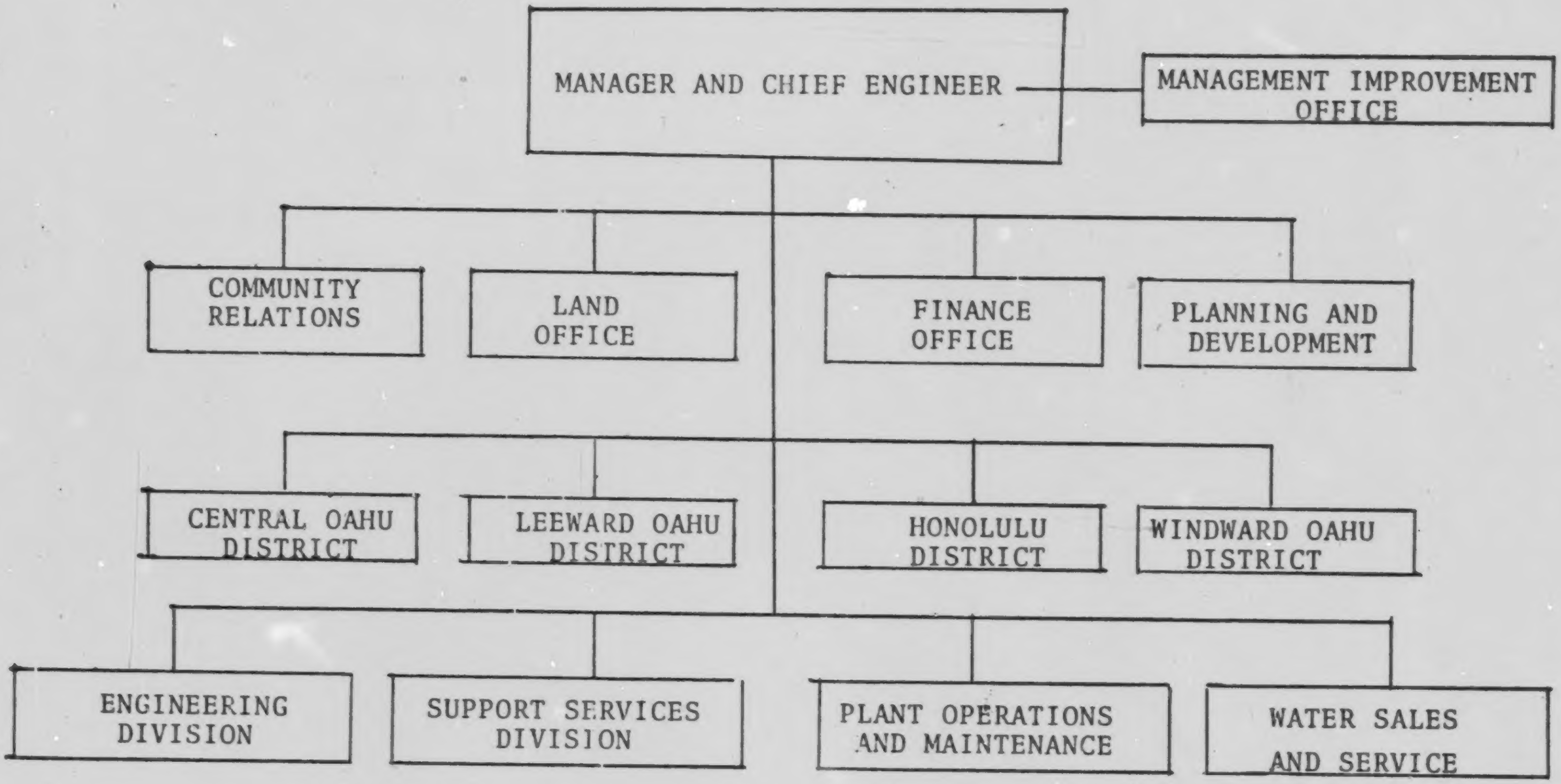

MANAGER AND CHIEF ENGINEER
MANAGEMENT IMPROVEMENT OFFICE
COMMUNITY RELATIONS
LAND OFFICE
FINANCE OFFICE
PLANNING AND DEVELOPMENT
CENTRAL OAHU DISTRICT
LEEWARD OAHU DISTRICT
HONOLULU DISTRICT
WINDWARD OAHU DISTRICT
ENGINEERING DIVISION
SUPPORT SERVICES DIVISION
PLANT OPERATIONS AND MAINTENANCE
WATER SALES AND SERVICE

CHART 3

EFFECT OF DISTRICTING

- Operations Division - - - - - - - - - Abolished
  - Plant Operations and Maintenance Section - - - - - - - - - - - - - - - - Become a Division
    - Automotive - - - - - - - - - - - - - Support Services Division
  - Distribution Section - - - - - - - - Abolished
    - Maintenance - - - - - - - - - - - - Abolished
      - Valves, Hydrants - - - - - - - All Districts
      - Building Maintenance - - - - Support Services Division
      - Groundskeeping - - - - - - - - All Districts
    - Construction - - - - - - - - - - - - Abolished
      - Emergency - - - - - - - - - - All Districts
      - Dispatching - - - - - - - - - Honolulu District
      - Heavy Construction - - - - - Honolulu District
      - Masonry - - - - - - - - - - - - Support Services Division
      - Carpentry - - - - - - - - - - Support Services Division
      - Heavy Equipment Operation - Support Services Division
    - Suburban Field Services - - - - - Abolished
      - Windward Yard - - - - - - - - Windward District
      - Leeward Yard - - - - - - - - - Leeward District
      - Central Yard - - - - - - - - - Central District

- Service and Meters - - - - - - - - Abolished
  - Meter Maintenance - - - - - Support Services Division
  - Service Connections - - - - All Districts
- Water Sales and Service Division
  - Investigation Section - - - - - - - - All Districts
- Planning, Resources and Research Division - - - - - - - - - - - - - - - Abolished
  - Microbiological Laboratory - - - - Plant Operations Division
  - Chemical Laboratory - - - - - - - - - Plant Operations Division
  - All Other Sections - - - - - - - - - - Planning and Development Office
- Engineering Division
  - Distribution Engineering Section - Planning and Development Office
  - Special and Major Projects Section - - - - - - - - - - - - - - - - - Planning and Development Office
  - Subdivision, State and City Improvement - - - - - - - - - - - - - - - Water Sales and Service Division

NEWLY ESTABLISHED

District: Honolulu, Windward, Central, Leeward

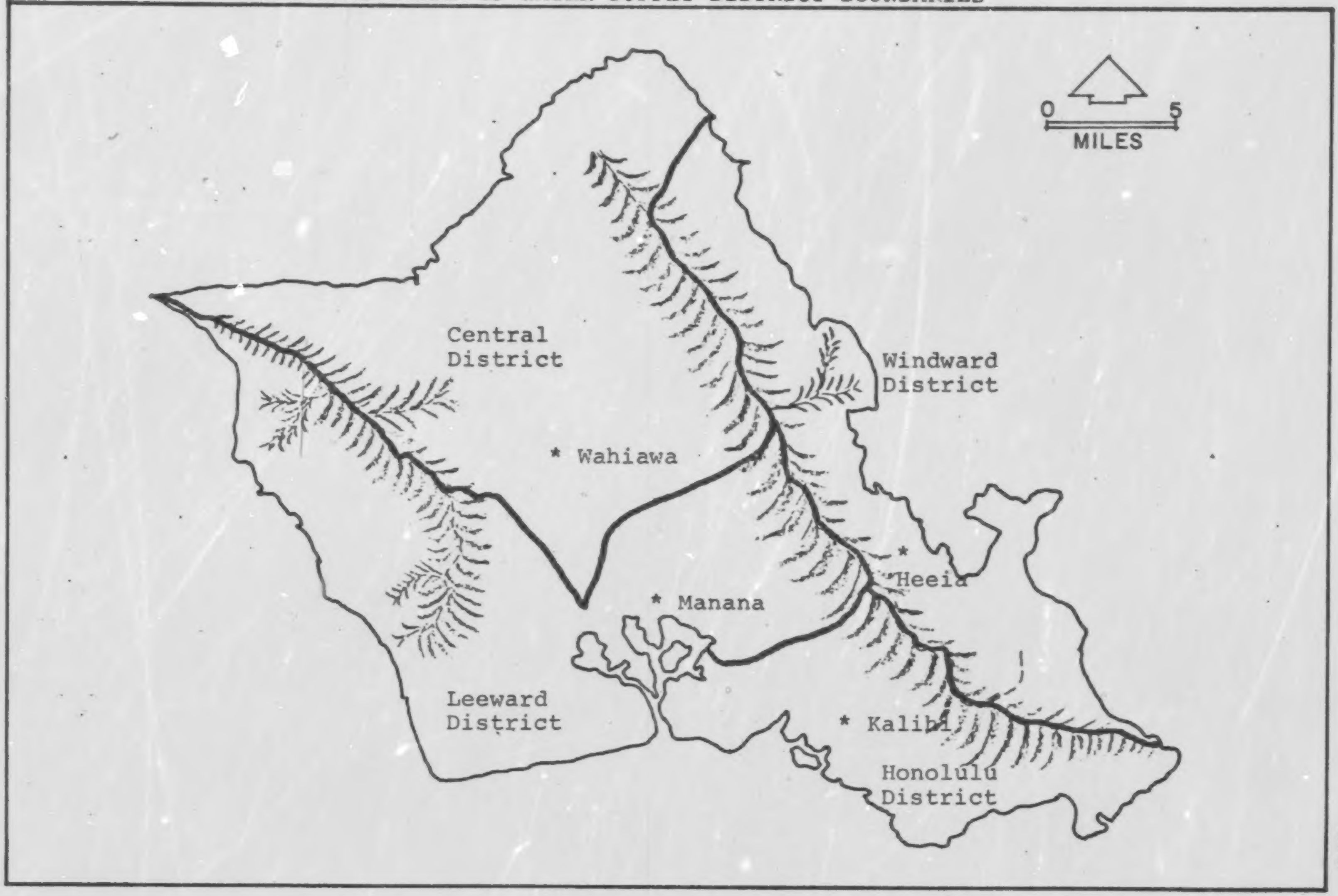
Office of Planning and Development

Operations Support Services Division

Management Improvement Office

MAP 7

PROPOSED BOARD OF WATER SUPPLY DISTRICT BOUNDARIES


0
5
MILES
Central District
Wahiawa
Windward District
Heeia
Manana
Leeward District
Kalihi
Honolulu District

In addition to providing more personal and convenient service to the public, the Districting Plan would contribute to operational efficiency. Some of the practical results of Districting as they relate to operations and costs are included in the following paragraphs:

1. Implementation of the Districting Plan provides an opportunity to reduce the excessive number of supervisory levels, provided that management acts decisively to eliminate some of these levels.
2. Travel time to and from job sites and overtime expenses can be cut significantly by placing more of the Board's service functions in the field and closer to where they are needed.
3. Vehicle and field equipment repair should be markedly improved and costs reduced by moving the Automotive Section from Beretania Street to the repair capability; major repairs will be handled at Kalihi.
4. The direct dispatch of vehicles and equipment from the Districts will reduce travel time, fuel consumption, tire wear, and wear and tear on vehicles.
5. Districting will result in quicker response to emergency situations and customer complaints.[39]

The Report of Districting Feasibility yielded some serendipitous benefits. For example, the study suggested that the Board consider having its groundskeeping functions performed by outside contractors. At present, annual groundskeeping expenses are as follows:

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[39] Ibid., pp. 54, 55.

Direct salary payments:	$250,000
Medical, retirement, FICA:	62,500
Vehicle, equipment, fuel:	200,000
TOTAL:	$512,500[40]

The Pritchard report suggests that this is an exorbitant amount of money to expend for a non-productive function.

Meter Repair could also be abandoned as a direct function of the Board of Water Supply work force. Meter repair costs about a quarter of a million dollars per year in salaries and fringe benefits. A good estimate of total operating costs for meter repair is about $500,000 annually. Mr. Pritchard speculated that if both meter maintenance and groundskeeping were contracted out, there could very well be a savings to water consumers on the order of $500,000 annually.[41]

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[40] Ibid., pp. 61, 62.

[41] Ibid., p. 62. Manager and Chief Engineer, Edward Hirata acted in December, 1974, to cut groundskeeping costs by recommending the transfer of the Board's Nuuanu plant nursery operations and six facilities totaling 5.99 acres of land to the Department of Parks and Recreation. At the present time, all of the lands and facilities in question are being used for parks purposes. Although the Department of Parks and Recreation will maintain the lands and provide recreational improvements, ownership and rights of access will remain with the Board of Water Supply. The transfer is expected to reduce the Board's groundskeeping expenses, and at the same time provide the public with enhanced recreational opportunities. Documents relating to the transfer are as follows: "A Review of Land Holdings, Requirements and Land Policies of the Board of Water Supply," a report released by the Board in June, 1968; Edward Hirata's letter of December 19, 1974, to the Board recommending the transfer;

At this writing, it is too soon to know whether the Board, its management and staff will respond positively toward Mr. Pritchard's concepts and recommendations. The writer believes that these management concepts and recommendations should be put into effect, and that the result will be beneficial to the Board and to its customers throughout Oahu.

It appears that savings from the Districting Plan and "belt-tightening" measures undertaken by Manager and Chief Engineer, Edward Hirata, will come too late to prevent a water rate increase July 1, 1975. The Board's most recent rate increase occurred in 1970. In September of that year, R. W. Beck and Associates recommended, and the Board adopted, the following schedule of rates:

A monthly service charge based on meter size plus:

$.37 per 1,000 gallons for the first 50,000 gallons,

.30 per 1,000 gallons for the next 350,000 gallons,

.22 per 1,000 gallons for the next 1,000,000 gallons,

.17 per 1,000 gallons for the next 1,400,000 gallons.[42]

Edward Hirata's letter of January 8, 1975, to Mayor Frank F. Fasi advising him of the proposed transfer of lands; and Mayor Fasi's letter of January 17, 1975, replying to the Manager and Chief Engineer and accepting the transfer in principle.

[42] R. W. Beck and Associates, Water Rate Study (Seattle, Washington, R. W. Beck and Associates, September, 1970), p. I-5.

In the Water Rate Study, R. W. Beck projected the Board's operating expenses and revenue requirements from fiscal year 1971 through fiscal year 1975, and stated that the new rates should be adequate to meet revenue requirements through June 30, 1976.[43] Unfortunately, R. W. Beck underestimated revenue requirements over the four year period ending June 30, 1974 by $1,979,000, or 3.2% of the Board's total operating revenue.[44] The Board discovered and publicized the existence of the revenue shortfall in November, 1974. At the Board's meeting of November 20, Manager and Chief Engineer reported that in view of the disparity between the projection and actual performance, the Board would be left with a balance of only $23,000 as of June 30, 1975. If the present rate structure were maintained after that time, there would be a $6,500,000 budget deficit by June 30, 1976. The writer, as Chairman of the Board of Water Supply, went on record with the following statement:

> In this time of recession and inflation we Board members dislike even the thought of increasing water rates.
>
> (But) without a rate increase we would be forced to initiate cutbacks in service and system

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[43] Ibid., p. I-7.

[44] Honolulu Board of Water Supply, "Comparison of Projected and Actual Operating Results as Projected in 1970 Rate Study Vs. Actual Four Years Ended 6/30/74" (Honolulu, Hawaii: Honolulu Board of Water Supply, November, 1974). The entire report is relevant. (Mimeographed.)

> improvements. Such actions would not be in the public interest.[45]

At the November 20 meeting, the Board authorized the firm of Brown and Caldwell to study the Board's revenue requirements and recommend a new schedule of water rates. On December 6, 1974, the Board received a letter from R. W. Beck and Associates explaining why their projection had been wide of the mark. For the four year period ending June 30, 1974, R. W. Beck underestimated operating expenses by 1.4% and overestimated metered water sales by 5.4%. Over 40% of the $1,979,000 deficit occurred in metered sales in FY 1974. Beck predicted an increase in revenue from metered sales of $626,000 for that year, when in fact revenues declined by $207,000. In fairness to Beck it should be pointed out that no one at the Board of Water Supply anticipated a decline in metered sales in FY 1974. R. W. Beck defended their 1970 Water Rate Study and its projections by maintaining that the variances in amounts over and under estimates are relatively small when the time span and general economic conditions are taken into account.[46] Nevertheless, the Board is faced with the need to raise water rates in order to maintain its solvency.

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[45] John Henry Felix, Statement by the Chairman of the Board of Water Supply on the subject of water rates. November 20, 1974.

[46] R. W. Beck and Associates, Letter to the Chairman and Members of the Board of Water Supply on the subject of water rates and revenue projections, December 6, 1974.

The writer is convinced after reviewing the evidence that the mishandling of the computer issue and the management deficiencies revealed in consultant Leo C. Pritchard's two reports have contributed to the threatened deficit.

Edward Hirata inherited a truly challenging management situation at the Board of Water Supply when he became Manager and Chief Engineer in March, 1974. During the past year, Mr. Hirata has earned the respect and confidence of every member of the Board. The members themselves are committed to providing the executive leadership necessary to ensure that the Board will carry out its responsibilities to the public both effectively and efficiently.

As a step toward meeting these responsibilities, the writer would like to conclude this chapter by offering a statement of the Board's primary responsibility and listing management objectives for the Board to attain.

The primary responsibility of the Board of Water Supply is to provide the people of Oahu with an ample supply of high quality water at the lowest possible price.

The management objectives of the Board should be:

1. The formulation of a comprehensive Water Policy as a guide to action.
2. Competent and effective administrative processes.
3. Full cost consciousness and cost control.
4. Continual review and improvement of the organization structure and functional relationships within the organization.

5. Effective communication between the Board and other government agencies, and between the Board and the public.[47]

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[47] Issues, Goals and Objectives for the Seventies and Beyond, published by the City and County of Honolulu, provides a model for the establishment of goals and objectives by municipal agencies.

Chapter 5

THE SEWER ISSUE

The question of whether to combine water supply operations with sewerage functions became an important Island-wide issue in the 1974 election campaign; it may become an important issue again in 1976.

The first 38 miles of Honolulu's sanitary sewer system was completed in 1901. From that year until 1913, the Territorial Board of Health operated the sewer system. In 1913, the Territorial Legislature authorized the transfer of water and sewer functions to the City and County of Honolulu. From 1925 to 1930 the Honolulu Sewer and Water Commission helped upgrade the administration of the system. In 1932, two years after the HS&WC merged into the Board of Water Supply, the Board turned over all sewer plans and records to the Department of Public Works, City and County of Honolulu. As mentioned in Chapter 2, Frederick Ohrt and his staff were primarily concerned with water supply, especially the conservation of water resources, and they favored returning sewer-related functions to the City so that they could concentrate fully on Oahu's water supply problems.

The sewer and water systems remained completely separated from 1932 to 1974.[1]

The sewerage system has expanded over the years to meet increasing demand: from 38 miles of sewer mains in 1901, to 175 miles in 1930, to over 300 miles in 1948. By late 1973 the system included eighteen sewage treatment plants, forty-two pumping stations and over 1,300 miles of sanitary sewer mains. While these figures show considerable growth and investment in Oahu's sewerage system, it should be kept in mind that no sewage treatment plants are presently serving metropolitan Honolulu. Over 55 million gallons of untreated sewerage are being discharged into the ocean through the Sand Island outfall every day. We can expect this situation to change within the next few years. When the United States Congress passed the Federal Water Pollution Control Act of 1972, the elimination of the discharge of pollutants into navigable waterways became a national goal. The Sand Island Sewage Treatment Plant is already under construction, and plans are well underway for the Honouliuli and Kaneohe-Kailua plants. The Sand Island Plant will have the capacity to treat 82 million gallons of sewage per day; the discharge of raw sewerage into the ocean off Honolulu will become a thing of the past.[2]

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[1] Brown and Caldwell, Study of Financial Policies and Sewerage Service Charges (Honolulu: Honolulu Board of Water Supply, 1973), pp. 2-1, 2-2, 2-4; George F. Nellist, "Building a Modern Water System," p. 3.

Although the Division of Sewers, Department of Public Works, operated the municipal sewer system from the 1930's until 1974, proposals were made from time to time to combine water supply and sewer functions on Oahu. During the late 1960's and early 1970's, such proposals began to receive serious consideration and significant support in the community.

In 1969, Mayor Frank F. Fasi asked the Board of Water Supply to carry out a study of the feasibility of consolidating the Division of Sewers under the Board. The Board submitted a detailed report in October, 1969. The report concluded that, "Under joint operations, the consolidation and elimination of duplicate functions and the completion of long-range programs on a fully coordinated basis could result in savings and public benefits in the form of improved water and sewer services." The report suggested that the success of a combined sewer-water administration on Oahu would depend on establishing a satisfactory method of funding sewer operations. Sewer operations could be fully subsidized by the City, or funded by assessing a sewer user charge, or by some combination of these two methods. The report recommended that, if a merger were to occur, the Board should be granted authority to establish sewer service charges and to sell bonds in order to finance capital improvements and operations.[3]

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[2] Brown and Caldwell, pp. 2-2, 2-6, 5-8, 5-11; U.S. Congress, Federal Water Pollution Control Act (P.L. 92-55); Izaak Walton League of America, A Citizen's Guide to Clean Water (Arlington, Va.: Izaak Walton League of America, under contract with the U.S. Environmental Protection Agency, 1973). The entire publication is relevant.

The Board's Report listed seven arguments favoring joint administration:

1. There would be improved control over design and engineering; both water and sewer operations utilize similar hydraulic facilities such as pumping stations, treatment plants and pipelines.
2. There would be increased effectiveness in terms of the prevention of water pollution and the reclamation of waste water.
3. There would be improved coordination in research, planning and construction.
4. The Board of Water Supply has the capability to handle billing and collection procedures for sewer service charges.
5. There would be a savings in manpower due to the joint use of personnel: inspectors, maintenance men, pump operators, technicians, groundskeepers, etc.
6. Integration would mean that the joint use of facilities, laboratories, field offices, yards and storerooms would become practical.
7. The integration of sewage pumping operations into the Board's telemetry, supervisory control and computer systems would be practical and would increase over all operational efficiency.

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[3] A Preliminary Feasibility Report on the Proposed Consolidation of the Division of Sewers, City and County Department of Public Works Under the Honolulu Board of Water Supply (Honolulu: Honolulu Board of Water Supply, 1969), pp. 3-5.

The main argument against joint administration boiled down to a potential public relations problem: people might oppose joint administration on the grounds that it would increase the possibility of sewerage contamination of fresh water supplies, pipelines, etc.[4] The Board's report made it clear that the weight of professional opinion favored the merger of the sewer system under the management of the Board of Water Supply.

In the Spring of 1972 two events occurred that were significant for the sewer-water merger and interesting as a case study in inter-governmental relations in Hawaii: the State Legislature considered Senate Bill 1437 which proposed the transfer of sewer functions to the Board of Water Supply; and the City Charter Commission voted to adopt a proposal mandating the transfer of the sewerage system from the Department of Public Works, City and County of Honolulu, to the Board of Water Supply. This proposal became part of the Revised Charter for the City and County, and was accepted by the voters in November, 1972.

The Revised Charter was written by a Charter Commission composed of responsible and knowledgeable citizens who met and deliberated for a year prior to the 1972 general elections. The members of the Commission wanted to increase the openness and responsiveness of the City government to the people of Oahu. The Commission hoped to shape a City government that could not only meet people's needs, but anticipate their needs for the future.[5]

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[4] Ibid., pp. 43, 44.

The Charter Commission considered the responsibilities of each agency of the City government. George Yuen, Manager and Chief Engineer of the Board of Water Supply, testified before the Commission and referred to an American Water Works Association (AWWA) Committee Report on the joint administration of water and sewerage facilities. The AWWA Report concluded that "many of the administrative and operating functions of the two services are in general so parallel that some form of joint operation is both economical and highly desirable." Many of the 1,079 cities joining in the study reported that joint administration provided better coordination as far as waste water recycling was concerned. Combined operations were judged significantly more economical in terms of administration, engineering and operations. And the study noted a significant nationwide trend toward combining water supply and waste water functions under a single administrative roof. Half of the cities with joint administration estimated savings resulting from joint administration of up to 39% for administration, engineering and design costs. Three out of five of the respondents estimated savings of up to 39% in operations, maintenance and collection costs.[6]

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[5] Final Report of the Charter Commission, City and County of Honolulu, 1971-1972 (Honolulu: Charter Commission, City and County of Honolulu), pp. 1, 7.

Mr. Yuen's testimony and the Board's reputation for efficiency provided the context for the Charter Commission's discussion of a transfer proposal. At the meeting of April 11, 1972, Commissioner Daniel Tuttle of the University of Hawaii, informed the members of the existence of Senate Bill 1437 then under consideration by the State Legislature. Senate Bill 1437 ordered the merger of county sewer operations with the county boards of water supply. Dr. Tuttle was convinced that the Bill was an unconstitutional violation of Article VII of the Hawaii State Constitution. The Article in question prevents the Legislature from transferring an agency from one department of the City to another:

> Charter provisions with respect to a political subdivision's executive, legislative and administrative structure and organization shall be superior to statutory provisions. . . .[7]

Dr. Tuttle advised the Charter Commission to consider a proposal that would transfer the functions of the Sewers Division, Department of Public Works, to the Board of Water

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[6] Committee on Joint Administration of Water and Sewerage Facilities, American Water Works Association, "Joint Administration Water/Wastewater Works," Journal of the American Water Works Association, Vol. 63, No. 4 (April, 1971), pp. 199-202.

[7] Hawaii, Constitution, Article VII, Section 2.

Supply in order to prevent any conflict between the City and the State over the passage of Senate Bill 1437.[8]

Mrs. Mildred Kosaki, Charter Commission Secretary, suggested that the Commission should at least consider the transfer of the BWS to the Sewers Division, Department of Public Works. Commissioner David Trask objected on the grounds that the Board is operated more efficiently than the Sewers Division. No evidence was brought forward to support this contention; nevertheless the members of the Commission accepted it. Mr. Trask moved for the tentative adoption of a proposal that would provide for the transfer of sewer operations to the Board of Water Supply within three years of the effective date of the Revised Charter. The record shows that Mr. Trask's motion was carried by the affirmative vote of all eight of the Commissioners present at the meeting.[9]

At the same time the Charter Commission was considering the transfer, the State Legislature was deliberating Senate Bill 1437. The Bill was the work of Senate President David McClung. Its aim was stated clearly and directly:

> The purpose of this Act is to transfer jurisdiction over waste disposal and sewerage systems from divisions or departments of counties to boards of

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[8] Charter Commission, City and County of Honolulu, Minutes of the Charter Commission Meetings, Meeting Number 54, April 11, 1972, p. 18.

[9] Ibid., pp. 18, 19.

water supply in counties with a population in excess of one hundred thousand.[10]

The rationale for the transfer was also clear. The Federal Water Quality Act of 1965 recognized the high cost of planning, building and operating modern sewage treatment facilities, and provided that the Federal government would reimburse States for up to 55% of the cost of new sewage treatment plants. But reimbursement was conditional upon the sound financing and management of the local sewerage system.

Senate Bill 1437 mandated the transfer to the Board of Water Supply because:

1. Wastewater disposal is closely related to water supply; both functions should be operated and administered by a single entity in the interest of efficiency, economy and public safety.
2. As an autonomous agency, the Board of Water Supply can issue revenue bonds on an incremental basis in order to finance the development of sewage treatment plants without undue hardship to the taxpayer.[11]

Hawaii had committed funds for the building of sewage treatment plants and Senate Bill 1437 was intended to provide protection for the State's investment.

Charter Commission Chairman, Andrew Ing, took a leading role in coordinating action between the Commission and the Legislature. He made sure that copies of the Commission's transfer proposal were made available to both Houses of the Legislature. He conferred with Senator McClung, and informed the Commission that the Senator was sympathetic to the opinion that the matter of the transfer should be solely within the jurisdiction of the Charter Commission and the City and County government. McClung pointed out that the Senate was primarily concerned with receiving reimbursement from the Federal Government for State funds committed to build sewage treatment facilities. And since the State had committed these funds, it had the right to transfer sewer functions from one department of the City to another. Dr. Tuttle's response to McClung's position was that the Legislature might indeed by able to provide for the funding aspect of building sewage treatment plants, but that right did not include the power to transfer functions from the Department of Public Works to the Board of Water Supply.[12]

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[10] Hawaii, Senate Bill 1437-72.

[11] Ibid.

The Legislature was satisfied that the purpose of protecting the State's investment in sewage treatment plants would be achieved by the Charter Commission's proposal to transfer sewerage operations to the Board of Water Supply. As a result, Senate Bill 1437 died in the House.

Article VII, Section 2, of the Hawaii State Constitution which prevents the Legislature from transferring Charter-mandated functions from one City department to another, has not yet been tested in the State Supreme Court.

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[12] Minutes of the Charter Commission Meetings, Meeting Number 55, April 13, 1972, pp. 11, 12.

In the opinion of the City Corporation Counsel, the Legislature has the authority to allocate responsibilities to the City, and it may remove functions from City control and return them to the State, but the Legislature may not transfer functions from one City department to another.[13]

In October, 1972, the United States Congress passed important amendments to the Federal Water Pollution Control Act. The new law provided that the States were no longer required to commit funds for the construction of sewage treatment plants. The Federal share of funding was raised to 75%, with local governments paying the remaining expenses. So, with the passage of the amendments to the Federal Water Pollution Control Act in the fall of 1972, the rationale for Senate Bill 1437, mandating the transfer of sewer operations to the Board of Water Supply in order to protect the State's financial commitments, no longer existed.[14]

On November 7, 1972, the voters accepted the Revised Charter by the following margin:

Yes	98,672	83%
No	20,274	17%[15]

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[13] Richard Sharpless, Corporation Counsel, telephone conversation of November 12, 1974, confirming a memorandum issued November 6, 1974.

[14] Federal Water Pollution Control Act, Public Law 92-500.

[15] Honolulu Advertiser, November 8, 1972, p. 1-1A.

Section 15-105 of the Revised Charter mandated "the orderly transfer to the Board of Water Supply . . . of the sanitary sewerage systems of the City." In June, 1973, the City Council passed a Resolution setting January 2, 1974, as the effective date of the transfer. On that date, the Board assumed the full responsibility for the planning, engineering, construction, operation and financing of the sewerage system.

The financial aspect of the merger became crucial. Operating expenses for the Sewers Division in Fiscal Year 1973 were $7.3 million, and these expenses could be expected to rise with the Island-wide modernization and expansion of the sewer system. Capital expenditures for the Sewers Division had averaged $5 million to $6 million, per year. But for the next several years the Board of Water Supply would have to spend an average of $11 million, per year. In order to meet Oahu's growing need for modern sewerage service, the magnitude of the capital improvements program would be unprecedented in the history of the City of Honolulu. Moreover, additional funds would be required to enable the Island-wide sewerage system to meet Federal and State water quality requirements.

Sewerage treatment plants will be especially expensive. The Sand Island plant will cost over $44 million; the Honouliuli plant, over $50 million; and the Kaneohe-Kailua plant, over $13 million. The Board would not have to shoulder the entire cost of these facilities. The Federal Water

Pollution Control Act will provide 75% of the funding, and the State of Hawaii can be counted on to pay 10%.[16] But in order to qualify for this Federal and State assistance, the Board would have to adopt a system of user charges to ensure that all of the recipients of waste treatment services pay their proportionate share of the costs of operating and maintaining the sewerage treatment facilities.[17] The concept of a sewer service user charge is based on the principle that, whenever possible, the individual or entity benefiting from a municipal service ought to pay a fair share of the cost of that service. It is an illusion to bury the cost of sewerage service among other municipal expenses financed by the City property tax. It is much more efficient to isolate the individual's share of the expenses when this is possible (and it is possible in the case of sewer services), and require the individual to pay an equitable user charge. When the citizen pays the user charge, he has an increased incentive to hold sewerage officials (and perhaps the city administration) responsible for the efficient operation of the sewer system.

The national trend is clearly toward the sewer service user charge. A survey conducted in 1969 by the American Water Works Association among 2,500 cities with populations exceeding 10,000 showed that the number of cities deriving revenues through a sewer service user charge had increased to 83% of the cities responding to the survey. Today that figure is closer to 90%.[18]

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[16] Hawaii, Revised Statutes, 1973, Act 119.

[17] Federal Water Pollution Control Act, 1972, Section 204; A Citizen's Guide to Clean Water, p. 32.

In March, 1973, the City Council authorized the firm of Brown and Caldwell, Consulting Engineers, to undertake a study of the waste water system and develop an equitable means of recovering the costs of operating the system. Brown and Caldwell completed their report in November, 1973. They recommended that the residents of a single family home be charged a base rate of $5.25 per month and .22 per 1,000 gallons of metered water consumption up to 11,000 gallons. Since the typical single family home on Oahu uses about 8,800 gallons of water per month, the average sewer service charge for residential users would be $7.19 per month. Charges for non-residential users would be based on the size of the water meter and on either the amount of metered water consumption, or metered waste water discharge. The charge for pumping a cesspool would be $18 per service.

Cesspool pumping has been a difficult problem for the City and County over the years. There are about 16,000 cesspools on the Island of Oahu. Approximately 9,000 of these are defective to some degree. Of these 9,000, two thirds require periodic pumping, and the remainder are treated chemically. Brown and Caldwell estimated that $18 would be a fair price for the occasional pumping of cesspools. They also recommended that a ceiling of $96 per year be placed on cesspool pumping costs so that even if a cesspool requires frequent pumping, the cost would not exceed the annual cost of the average sewer service user charge. There was no intent to penalize residents using faulty cesspools. The Board's objective was to eliminate as many of these defective cesspools as possible by extending modern sewer services throughout the Island during the next several years.[19]

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[18] Committee on Joint Administration of Water and Sewerage Facilities, American Water Works Association, Vol. 63, No. 4 (April, 1971), pp. 199-202; Honolulu Board of Water Supply, "Board of Water Supply Statement to the Council," Honolulu, January 22, 1974. (Mimeographed.)

The writer was convinced that the schedule of rates proposed by Brown and Caldwell were fair and reasonable in their application to all sewer service customers. As Chairman of the Board of Water Supply, the writer went before the public on three occasions in early December, 1973, to inform the community about the need for sewer service user charges. The public was invited to testify and comment on the proposed charges at a hearing extending over three evenings, in three major population centers of the Island: Leeward Oahu, Windward Oahu and Central Honolulu. Section 7-110 of the City Charter permits the Board to hold public hearings at its own convenience in the Board's Public Service Building.

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[19] Brown and Caldwell, pp. 8-16 to 8-20, 11-15.

But the members of the Board intended to go beyond the letter of the law and provide a meaningful public forum at times and places convenient for the people of Oahu.[20]

The public hearings were well attended, and they became the forum for some spirited discussion. Several citizens testified against the proposed charges on the grounds that the proposed rates would penalize homeowners using water to irrigate their lawns and trees. After all, they contended, irrigation water does not constitute sewage, so why should they be required to pay a sewer service user charge on the basis of their monthly water consumption? John Luthin, of Brown and Caldwell, replied that it is practically impossible to measure residential sewage on a metered basis, there is not a city in the nation that meters residential waste water, and that his firm is justified in assuming that the amount of water taken into a home is proportionate to the amount of water that goes into the sewerage system.[21]

Leeward residents were particularly concerned about the proposed user charges. Several of them contended that the charges would be particularly burdensome since the Leeward side of the Island is relatively dry, and lawns require somewhat more irrigation in Leeward Oahu. Other Leeward residents complained that the $18 cesspool pumping charge would be unfair to people in their district because of the high number of cesspools on the Leeward side. As Chairman of the Board of Water Supply, the writer assured the citizens that the $18 pumping charge would be used to improve service (in fact, while cesspool pumping was under the Board's administration, the waiting period for cesspool pumping was reduced from upwards of ten days to just a single day in most parts of the Island).[22] The writer advised the citizens that the sewer service user charges are needed if Oahu's sewer system is to qualify for Federal funding and comply with Federal and State law.[23]

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[20] Honolulu Board of Water Supply, "Opening Statement by John Henry Felix at Public Hearings on Proposed Sewer System User Charges," Honolulu, December 6, 1973. (Mimeographed.)

[21] Honolulu Advertiser, December 5, 1973, p. 1.

Our efforts notwithstanding, the public reaction in the Leeward District was particularly negative. This reaction was especially significant because Leeward residents found a leading Island political figure, George Akahane, the City Councilman representing Leeward Oahu, to lead the battle against the sewer user charge.

At the December 6 hearing at Washington Intermediate School in central Honolulu, businessmen raised important objections to the proposed charges. Del Monte and Dole officials pointed out that their companies already operate at an annual loss, and the additional charges could affect their ability to conduct business on Oahu. Hawaiian Tuna Packers, Ltd., Meadow Gold Dairies, apartment and hotel owners spoke of reduced profits and the necessity of having to pass some of the user charge on to their customers. Fred Bennion, Director of the Tax Foundation of Hawaii, suggested that the Board reduce the proposed charge by lowering the $5.25 minimum monthly rate and relying more on additional metered charges. Bennion also suggested that some scheduled sewer projects be delayed in order to reduce the tax burden on Oahu residents. City Councilman, Frank Loo, told the meeting that he had asked the City Council's research office, the Office of Council Services, to examine "the inequities" in the proposed sewer service user charges.[24]

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[22] Honolulu Board of Water Supply, B.W.S. Weekly News Summary, Vol. 2, No. 43, November 8, 1974.

[23] Honolulu Advertiser, December 6, 1973, p. A1.

On January 22, 1974, the writer went before the City Council to make, once again, the case for proceeding with the merger and adopting the proposed sewer service user charges:

> This entire matter has been considered by the Charter Commission and voted on by the people. To delay or rescind the user charge would result in costly delays in the capital program. In addition, it would be contrary to the EPA requirement that a service charge must be, or will be, in force before Federal Funds will be granted. To reconsider the entire proposition at this time would be costly, would endanger our qualifications for Federal Funds, and would be a serious blow to the morale of our employees. Since a service charge must be imposed regardless of whether the sewer function is located

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[24] Ibid., December 7, 1973, p. B1.

> in the Board of Water Supply or some place else, we believe we should be allowed to proceed. . . .[25]

Two weeks later, at the February 7 meeting of the Board of Water Supply, the Board formally adopted the sewer service user charges and set April, 1974, as the date when these charges would become effective. City Managing Director, Paul Devens, appeared at the meeting and assured the Board and the public that the City Administration is committed to reducing property taxes to offset the sewer service user charge.[26]

At the City Council meeting of March 19, less than two weeks before the effective date of the new charges, Councilman George Akahane introduced two momentous resolutions. The first called for the postponement of the effective date of the sewer user charge from April 1, to December 31, after the November elections. The second resolution would allow the voters in the November elections to transfer sewer operations back to the Department of Public Works. Councilman Akahane made his position clear at a Board of Water Supply meeting on March 28:

> I agree that the most efficient way is to put water operations under one roof. I feel very strongly, and I am speaking as just one Councilman, that all water operations should be under City supervision. . . .
>
> The transfer of the sewers to the Board of Water Supply was included in the revised City Charter

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[25] Honolulu Board of Water Supply, "Board of Water Supply Statement to the Council," Honolulu, January 22, 1974. (Mimeographed.)

[26] Honolulu Advertiser, February 8, 1974, pp. A1, A6.

> approved by the voters in 1972. All issues were lumped together. . . . One of the unfortunate things in the Charter is that people voted for the transfer without knowing a sewer charge was to follow.[27]

There is a good deal of merit to Councilman Akahane's position. In the chapter on institutional response to water supply needs, the writer discusses the relative merits of three alternative directions for Oahu's water supply system: modified semi-autonomous status; private ownership; and, as Councilman Akahane has suggested, operation of the system by the City and County. The writer has consistently and publicly maintained that these three alternatives should be carefully and objectively examined; the public should be well informed about them, and the electorate should have the opportunity to make an intelligent and informed choice among the alternatives.

At the same time, as Chairman of the Board of Water Supply, the writer was committed to implementing the merger of sewer operations with water supply functions within the existing semi-autonomous framework. The electorate had mandated the transfer to the Board in November, 1972; and it was clear that a sewer service user charge was essential to the lawful and effective operation of the sewerage system.

The time had come to let the City Council and the public know that the Board would not give up the merger without a fight. At the April 11, 1974 meeting, the Board voted to request the City Council to rescind the two resolutions introduced by Councilman Akahane: the resolution delaying the effective date of the sewer service user charges, and the resolution that would put a Charter amendment on the November ballot calling for the return of sewer operations to the Department of Public Works.[28]

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[27] Honolulu Star-Bulletin, March 28, 1974.

At the City Council meeting of April 23, six of the nine Councilmen indicated that since sewer service user charges constitute a form of taxation, these charges should be set by the Council as the elected representatives of the people, and not by an appointive Board. Douglas Carlson, the _Advertiser_'s City Hall Writer, expressed the opinion that the Council majority was moving toward placing a Charter amendment on the November ballot calling for the Board of Water Supply to relinquish its semi-autonomous status and come under the direction of the City Council.[29]

The Board met two days later and Manager and Chief Engineer, Edward Hirata, served notice to the Council that delaying the effective date of the sewer service user charges to the end of the year would be an expensive proposition:

> I think the City Council should be made fully aware of the impact of its actions. Since they have deferred the sewer user charges for nine months, I think they have an obligation to pick up the ball and reimburse us for what we've already spent.

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[28] _Honolulu Advertiser_, April 12, 1974, p. B1.

[29] Ibid., April 26, 1974, p. A8.

Mr. Hirata estimated that the Board had already spent $728,000 on the merger.[30]

At the same April 25 meeting, the Board took up an important legal question. The Board had asked the Corporation Counsel, which normally provides legal services for the Board, for an opinion as to whether the Board, or the City Council, has the authority to set the effective date for sewer service charges. The Corporation Counsel had answered that although the Board may determine the rate of charges, the City Council has the right to set the effective date. The Board was not satisfied with this reply, and, at the April 25 meeting, voted to seek an outside legal opinion. Later that day, Yoshiaki Nakamoto, First Deputy Corporation Counsel, advised the Board that Section 7-116 of the City Charter prohibits the Board from obtaining outside legal assistance since litigation is not involved in the matter under discussion. Although the Board was effectively blocked from seeking outside legal assistance, the Board's April meetings constituted a determined effort to prevent the dissolution of the sewer-water merger.[31]

The Board and the City maintained their positions throughout the summer months. Councilman Akahane's April resolutions passed the Council, and early in September the Board voted unanimously to oppose the City Charter amendment that would appear on the ballot in November calling for the transfer of the Sewers Division back to the Department of Public Works.[32]

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[30] Honolulu Advertiser, April 26, 1974, p. A8; Honolulu Star-Bulletin, April 26, 1974, p. A14.

[31] Honolulu Advertiser, April 26, 1974, p. A14; telephone conversation with Yoshiaki Nakamoto, Deputy Corporation Counsel, April 25, 1974.

A week later, by a vote of 4-4 (with a majority needed for passage), the City Council's Committee of the Whole refused to vote out Councilman Akahane's resolution to amend the City Charter and create a new City Department of Water. Thus the issue for the voters to decide in November was whether sewer operations would remain with the Board, or be transferred back to the City.[33]

On October 23, 1974, less than two weeks before the general elections, Councilman Akahane presented his position to the voters in the Advertiser's "Commentary" column:

> If voters vote on General Election Day in favor of returning the sewers program to the City, the sewer use fee may be deferred to 1978 or thereafter. Further, the amount to be charged thereafter could be about $1.35 at today's costs, whereas the amount that each family will be assessed by the Board of Water Supply effective December 31, 1974, if voters reject the transfer, is $7.67 per month at today's cost.[34]

In the opinion of the writer, Akahane's position ignored the value of combined operations, and ignored the fact that the costs of building and operating a modern sewerage system are unavoidable; they will have to be paid one way or another in order for Oahu to comply with Federal law. Nonetheless, the writer and the Board recognized the attractiveness of Akahane's argument to an electorate already feeling the ill effects of inflation. The Board remembered the spirited opposition to the proposed sewer user charges at the public hearings in December, 1973.

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[32] Honolulu Advertiser, September 10, 1974, p. A8.

[33] Ibid., September 18, 1974, p. A8.

[34] Ibid., October 23, 1974, p. A15.

The Board had been trying to inform the public about the sewer issue from the time of the public hearing through the spring and summer of 1974. On October 3, 1974, with the election still a month away, the members of the Board agreed to appropriate $10,000 for a public information campaign against the Charter amendment. The Board based this appropriation on an oral opinion from Deputy Corporation Counsel Nakamoto, that the expenditure would be proper. A few days later, the Deputy Corporation Counsel issued a written opinion to the effect that the expenditure of public funds for the information effort would be illegal. He maintained that he had issued his oral opinion without fully understanding the purpose of the appropriation. Mr. Nakamoto prohibited the use of public funds on the ground that the information effort would serve a partisan purpose, not a public one. He cited Campbell V. Stainback, 38 Hawaii 310, and his own ruling of January 26, 1970, prohibiting the City Council from using public funds to support the reapportionment of the City Council, as precedent for his decision.[35]

In order to comply with the written opinion, the Board voted to rescind the appropriation at a special meeting held October 16. By rescinding his original opinion, the Deputy Corporation Counsel dealt the Board a real setback. Valuable time was lost in the effort to launch a "home stretch" information campaign prior to the election. The Board was prevented from including an informational leaflet in the October billing to water customers. In addition, the decision meant that the Board could no longer be certain of having adequate funds to purchase newspaper space and radio time.

The reversal of opinion caused the Board significant public embarrassment. The Star-Bulletin and Advertiser editorialized that the Board had acted in a questionable manner by deciding to appropriate $10,000 for the public information campaign. The newspaper placed itself in a somewhat contradictory position by expressing a lack of confidence in the Board, while at the same time supporting the Board's attempt to retain combined sewer-water operations.[36]

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[35] Honolulu Advertiser, October 17, 1974, p. A7; Edward Y. Hirata, Letter to the Honolulu Board of Water Supply, October 16, 1974; Yoshiaki Nakamoto, memorandum to Ron Bennett, Administrative Assistant to the City Council Chairman, January 26, 1970.

[36] Star-Bulletin & Advertiser, October 20, 1974, p. B2.

Despite this unwarranted criticism, and in view of their own commitment to keep water and sewer operations together, the five appointed members of the Board, acting as individuals, formed a committee to fight the proposed Charter amendment. The Committee for Combined Water and Sewer Operations spent approximately $3,000 for newspaper announcements and radio time during the week preceding election day. The newspaper announcements printed Question 1, "Shall the City Charter be amended to return the Division of Sewers from the Board of Water Supply back to the Department of Public Works of the City and County of Honolulu?" and asked the electorate to vote "No" for four reasons:

1. The transfer would result in the loss of close to one million dollars already invested in the merger.
2. A "No" vote would mean lower over-all costs of administration and operation.
3. It would also mean better control of water pollution.
4. And it would mean controlled development of water re-use.

A total of 30 sixty-second announcements on three popular Honolulu radio stations carried substantially the same message.[37]

In the closing days of the campaign, the Chamber of Commerce of Hawaii, the Hawaii State Federation of Labor and

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[37] Statement from Fawcett-McDermott Associates, Inc., to the Committee for Combined Water and Sewer Operations, November 10, 1974; Honolulu Advertiser, October 31, 1974, p. All.

International Longshoremen's and Warehousemen's Union (ILWU), Local 142 joined the Star-Bulletin, the Advertiser and the Committee for Combined Water and Sewer Operations in publicly endorsing a "No" vote on the proposed Charter amendment.

On Election Day the voting was so close on Question 1 that it was late in the evening before the results were clear:

"Yes"	on Question 1:	93,944
"No"	on Question 1:	91,051[38]

By a narrow margin the voters had decided to at least temporarily separate sewer services from water supply functions on Oahu. An analysis of the voting returns shows a heavy "Yes" majority in Pearl City, Ewa, Waipahu and Waianae. The same Leeward areas of Oahu that had opposed the sewer user charges at the public hearings provided the votes to send sewer operations back to the Department of Public Works. At least the Committee for Combined Water and Sewer Operations could take some consolation from the fact that the public information campaign was effective even though it had been hampered by the Deputy Corporation Counsel's decision prohibiting the use of Board funds. The absentee voters, those who had not been exposed to the

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[38] Eileen K. Lota, City Clerk's Certification of Election Results, Honolulu, Hawaii, November 26, 1974.

Committee's information campaign, voted "Yes" by a 60% to 40% margin. Among the voters who cast their ballots on Election Day (and who had been exposed to the informational program), the results showed a razor thin margin of "Yes" votes:

"Yes"	90,955 or 50.6%
"No"	89,074 or 49.4%[39]

The writer cannot help but think that given a little more time, and a little more money, the Committee could have reached more people, more often, and the "No" vote would have prevailed.

Precincts with a high concentration of defective cesspools voted "Yes" on Question 1. Brown and Caldwell cited three such areas where cesspools will not be replaced by a modern sewerage system for several years due to the unavailability of Federal financial aid: Ewa Beach, Kahaluu and Waialua-Haleiwa. Precincts in these areas voted as follows:

Precinct Location	Question 1	
	Yes	No
Ewa Beach Elementary School	538	343
Ilima School, Ewa Beach	1,168	707
Kahaluu School	786	630

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[39] Office of the Lt. Governor, Unofficial General Election Results, Honolulu, Hawaii, November 5, 1974.

Waialua High School	650	603
Haleiwa Elementary School	457	400
	3,599	2,683
	57.3%	42.7%[40]

In the final analysis, in the writer's opinion, most of the 93,944 people who voted "Yes" did so because they wanted to save money on the sewer user charge, not because they believe that sewerage operations and water supply operations ought to be kept separate, and not because of any loss of confidence in the Board's leadership. In the days following the election, Mayor Fasi and Councilman Akahane, looking ahead to the 1976 elections, re-confirmed their position that water and sewer operations should be administered under one roof, and that Oahu's water supply agency should be a Department of the City and County.

On December 31, 1974, the Board of Water Supply relinquished control of sewer operations to the Department of Public Works. Three days later, the Honolulu Star-Bulletin printed an editorial on eleven fundamental problems for Honolulu's future. One of the problem areas was sewers and water:

> The Charter amendment returning the Sewers Division to the Public Works Department leaves sewer and water administration separate. Long-term recycling

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[40] Brown and Caldwell, pp. 10-7; Unofficial General Election Results, November 5, 1974.

> needs suggest (the City) Council will have to consider getting them back together.[41]

The editorial leaves a basic question unanswered: Does the Star-Bulletin favor combined operations under the Board of Water Supply, or under the City and County? In either case, the writer hopes that during the next eighteen months the public will have a genuine opportunity to examine the merits of combined sewer-water operations, and the merits of the several institutional directions open to Oahu's water supply system.

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[41] Honolulu Star-Bulletin, January 3, 1975, p. A20.

Chapter 6

INSTITUTIONAL RESPONSES TO WATER SUPPLY NEEDS

Institutional responses to water supply needs are at least as important as technological responses. Institutional responses may occur at the municipal (Island-wide) level, at the Statewide level, and in the area of relationships between municipalities and the State.

There are several institutional goals as far as water supply functions on Oahu are concerned:

1. To improve the water supply agency's accountability to the public.
2. To increase operational efficiency so that high quality water supply service is maintained at the lowest cost to the public.
3. To improve the short-range and long-range coordination of water supply functions with other municipal functions.
4. To improve communications with state agencies.

In order to achieve these goals, there are three basic institutional options at the municipal level:

1. Modified semi-autonomous status (recommended modifications a. through e. are listed below).
2. Private ownership and operation.
3. Operation as a Department of the City and County.

The first option is to maintain the semi-autonomous status of the Board of Water Supply, but modify the Board's operations by taking some, or all of the following steps:

a. The first step is to open a meaningful dialogue with the City Council. In testimony before the City Council on September 17, 1974, the writer pointed to specific areas in which communications should be established on an ongoing basis between the City Council and the Board of Water Supply. The Council recognizes the need for this dialogue and we have continued the dialogue in subsequent meetings. The opening of communications with the City Council is unprecedented in the history of the Board of Water Supply. It is accurate to say that many opportunities for understanding and communication between the Board and the City Council have been lost over the years because the Board has guarded its independence too jealously. Water supply activities must be seen in the perspective of Island-wide planning and service activities. As demand on Oahu's finite water resources increases, the relative insularity enjoyed by the Board in the past has become a "luxury" that neither the Board nor the community can afford.

b. A second step is to open and maintain a dialogue with the City Administration. As Chairman of the Board of Water Supply, the writer has been concerned about improving the coordination of the Board's activities with those of the Department of General Planning, Department of Land Utilization, Department of Public Works, the Department of Housing and Community Development and other Departments of the City and County.

In a letter written October 18, 1974, the writer made the following suggestion to Mayor Fasi:

> I recommend that a Coordinating Committee composed of representatives from the City Administration, the City Council and the Board of Water Supply be formed for the purpose of forging a closer working relationship between our agencies, the objective

being to better integrate water and sewer planning into overall City programs.

Section 5-404 of the City Charter authorizes an Executive Planning Committee consisting of the Chief Planning Officer, the Managing Director, the Chief Budget Officer and "such other members of the executive branch as the Mayor may appoint." The purpose of the Executive Planning Committee is as follows:

> (To) assist the Department of General Planning by providing information as to the needs of the City. It shall also assist and advise the Mayor and Departments in determining priorities, in evaluating studies and new programs and in developing programs. . . .[1]

Although the Executive Planning Committee has not been active, it is a potential vehicle for the coordination of Board of Water Supply planning and operations with the activities of the municipal government. In a letter written November 17, 1974, the writer recommended to Mayor Fasi that the Manager and Chief Engineer of the Board of Water Supply be appointed to the Executive Planning Committee in order to achieve a closer working relationship between the Board and the City Administration. The writer recommended that the Public Works Director also be appointed to the Committee in order to maintain a close working relationship between water supply and waste water disposal functions. On December 5, 1974, Mayor Fasi acted on this recommendation by appointing Mr. Hirata and Mr. Kazu Hayashida, the Public Works Director, to serve on the Executive Planning Committee.[2]

c. A third step is to open and maintain a dialogue between the Board and the State

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[1] City and County of Honolulu, Revised Charter of the City of Honolulu, Hawaii, 1973, p. 17.

[2] Frank F. Fasi, letter from the Mayor to Robert Way, Chief Planning Officer, City and County of Honolulu, December 5, 1974.

Department of Land and Natural Resources (DLNR). Historically, the Board has failed to utilize the substantial research and applied development capability of the Division of Water and Land Development, DLNR. At a time when research activities are increasingly complex, and increasingly costly, it is essential for the Board to cooperate fully with DLNR and all public and private agencies and institutions that are involved in providing financial support and technical assistance for water supply and water resources research.

The year 1974 saw the first meaningful interaction between the Board and DLNR that anyone can remember. Manager and Chief Engineer, Edward Hirata, worked closely with Robert Chuck, Director of the Division of Water and Land Development, to coordinate the April, 1974, meeting of the Oahu Water Users Association. This meeting in itself signalled a new willingness on the part of the BWS to communicate with public and private entities that share a vital concern for Oahu's water resources.

Another sign of changing attitudes toward inter-governmental relations on the part of the Board's management is the fact that, for the first time in history, the Board is cooperating with the Division of Water and Land Development in order to obtain funds for water resource development on Oahu from the State Legislature.[3]

There are several reasons why there has been so little fruitful interaction between the Board and DLNR. From the Statewide perspective, the Honolulu Board of Water Supply enjoys the immense financial and administrative advantages that result from the presence of a concentrated population of water users. On the other hand, large areas of the Neighbor Islands lack the concentrations of people that make a modern water supply system economically feasible. In order to compensate for this situation, the State has directed its water resource effort primarily toward the Neighbor Islands. Another reason for the minimal interaction of the Board with DLNR over the years is that Board management has simply failed to seek the cooperation of DLNR until the past year; the Board has had a "go-it-alone" attitude. In addition, personalities have played a considerable role in this lack of communication. The objective should be to structure institutional relationships so that personal relationships (or lack of them) do not prevent the coordination of water-related activities. Communication should not depend merely on the presence of like-minded managers in leadership positions; it should be built into the structure of institutional relationships. Communication must become routine. Water supply is too vital a function to leave the coordination of water-related activities to chance.

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[3] Interview with Edward Hirata, Honolulu Board of Water Supply, November 4, 1974; interview with Robert Chuck, Division of Water and Land Development, November 4, 1974.

The Hawaii Ground Water Use Act provides for the institutionalization of communication between the Board of Water Supply and DLNR. Section 4 of the Act states that the Manager of the Board of Water Supply shall be invited to participate as an ex-officio member at all meetings of the Board of Land and Natural Resources whenever ground water resources are being considered.[4]

Although the law provides very clearly for this institutionalization of contact between the Board of Water Supply and the Board of Land and Natural Resources (BLNR), the BLNR has not invited the Manager of the Board of Water Supply to any of its meetings. In order to assure compliance with the law, and increase the opportunities for communication, the writer has asked the Manager of the Board of Water Supply to request an invitation from BLNR so that he may attend all future meetings relevant to ground water resources and development.

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[4] Hawaii, Revised Statutes, Chapter 177, Section 4.

d. A fourth step is to increase the accountability of the Board of Water Supply to the elected representatives of the people by granting the City Council some, or all, of the following powers:

   (1) Authority to veto any decision made by the Board of Water Supply (a 2/3 majority of Council members would be required to veto, and the Council would have up to 30 days to veto a decision of the Board).

   (2) Authority to veto a Board decision to raise or lower water rates, and/or authority to veto a Board decision to issue revenue bonds, and/or authority to veto the Board's annual operating and capital improvements budgets, and/or authority to veto Rules and Regulations issued by the Board.

   (3) Authority to appoint an independent audit of the financial affairs of the Board of Water Supply. Section 7-107 of the City Charter presently holds the Board responsible for appointing a certified public accountant to make an annual audit of the Board's financial status. The writer proposes that the City Charter be amended to grant the City Council the authority to contract for this annual audit.

Checks and balances are an important aspect of the American government system. No public agency should be isolated from the checks and balances that have contributed so much to the equity, durability and flexibility of our democratic institutions. The writer proposes that the accountability of the Board of Water Supply be increased, and its semi-autonomous status modified by the adoption of City Charter amendments embodying some combination of the above suggestions.

e. A fifth step is to raise the level of professional expertise of the members of the

Board of Water Supply by enacting the following:

(1) A revision of Chapter 54, Section 12, Hawaii Revised Statutes, to require the Mayor of each county to select members of the county board of water supply according to specific professional criteria. Under this concept, one Board member would be a registered engineer, the second would be a certified public accountant, the third would be a practicing attorney, the fourth would be a registered planner, and the fifth, a qualified administrator. Each member would be required to have at least five years of experience in his area of expertise. And each of the five appointed members would receive fair compensation for his professional services.

(2) A revision of Chapter 54, Section 12, Hawaii Revised Statutes enabling the Director of the Division of Water and Land Development to serve as an ex-officio member of the Honolulu Board of Water Supply. At present, the State's ex-officio representative on the Board is the Director of the State Department of Transportation. The writer suggests that the Director of the Division of Water and Land Development, DLNR, is much more intimately concerned with water resource conservation and development than the Director of the Department of Transportation. The Hawaii Ground Water Use Act, Chapter 177, Hawaii Revised Statutes, recognizes the role of the Department of Land and Natural Resources in the water resource field. It is time that the ex-officio membership of the Honolulu Board of Water Supply reflect the coordination of State and municipal water development activities that the Legislature intended when it passed the Ground Water Use Act.

The above recommendations, a. through e. should provide for improved inter-governmental communication, increased professionalization of the membership of the Board, and various modifications of the Board's semi-autonomous status. A second institutional direction should also be considered: the operation of Oahu's water supply system as a private enterprise. There are some real advantages to this proposal. For one, Oahu's water supply agency would come under the extensive regulatory authority of the State Public Utilities Commission (PUC). Chapter 269, Section 7, Hawaii Revised Statutes, indicates the extent of the power of the PUC:

> The Public Utilities Commission and each Commissioner shall have power to examine into the condition of each public utility, the manner in which it is operated with reference to the safety or accommodation of the public, the safety, working hours, and wages of its employees, the fares and rates charged by it, the value of its physical property, the issuance by it of stocks and bonds, and the disposition of the proceeds thereof, the amount and disposition of its income, and all its financial transactions, its business relations with other persons, companies, or corporations, its compliance with all applicable state and federal laws and with the provisions of its franchise, charter and articles of association, if any, its classifications, rules, regulations, practices, and service, and all matters of every nature affecting the relations and transactions between it and the public. . . .

In addition to the accountability provided by PUC regulation, the Oahu water supply agency, as a private enterprise, would be held accountable to its stockholders. Moreover, the incentives involved in operating the utility as a private enterprise can be expected to increase the agency's productivity. Another advantage to this proposal is that the sale of the assets of the Board of Water Supply would bring a great deal of money into the treasury of the City and County. At the close of fiscal 1974, the net worth of the Board of Water Supply amounted to $136,602,372.[5]

There are several disadvantages to the proposal to bring Oahu's water supply system under private ownership and operation. One objection is historical: during the 19th Century there was a nationwide tendency to abolish private ownership of water supply utilities in favor of public ownership. The reason for this trend was that privately owned utilities occasionally failed to meet the water supply needs of some members of the community on the grounds that providing first class service would not be profitable. Today, with the regulatory authority of Public Utility Commissions, there is no reason to believe that a privately owned water supply utility would fail to meet its responsibilities to the entire community.[6]

A more substantial difficulty is that the process of moving from municipal ownership would be highly complex. At present, the Board's employees are protected by civil service. Many of our employees would be reluctant to give up this security in order to work for a private water supply agency. Board of Water Supply employees are members of the 22,000 member Hawaii Government Employees' Association. As cited in Chapter 5, HGEA Executive Director, David Trask is known to favor maintaining the Board's semi-autonomous status. It would be unrealistic to expect the HGEA to react favorably toward a proposal to turn Oahu's water supply agency over to private management.

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[5] Honolulu Board of Water Supply, Annual Auditor's Report for Fiscal Year 1974. The entire report is relevant to a consideration of the Board's net worth.

[6] Based on a reading of the Annual Reports of the Indianapolis Water Company and the Louisville Water Company, Inc., the writer offers these two agencies as examples of first class, privately owned and operated water supply utilities.

Over the years the Board has acquired a good deal of land from the State in order to meet the water supply needs of the community. The State granted these lands with the full realization that the Board is a municipal entity. It is reasonable to assume that in the process of moving toward private ownership, the disposition of State lands granted to the Board would be highly complex; perhaps it would be prohibitively difficult.

There is yet another difficulty. The City Council, and for that matter, many members of the State Legislature, are committed to the belief that operating the water supply system is as much a municipal function as providing police and fire protection and other basic City and County services. Although there are some real advantages to private operation it would be realistic to expect considerable opposition from the City Administration and the City Council on philosophical and practical grounds.

Recalling some of the goals of institutional change: improving accountability to the public, increasing operational efficiency, and improving the short and long range coordination of water-related functions with other municipal agencies, there is a third possibility in addition to either modified semi-autonomous status, or private ownership. The Oahu water supply system could become a Department of the City and County.

One advantage of such a proposal would be that the operation of the water supply agency would be fully accountable to the elected representatives of the people. The City Council would provide the same detailed regulation of the City and County water supply agency that the Public Utilities Commission provides for privately owned utilities. The City Council would supervise the agency's operation and it would determine water rates. The Mayor would be held accountable to the electorate every four years for the operation of the water supply agency. The coordination of short and long term water-related activities with other municipal functions would be enhanced by removing an institutional barrier to coordination: the Board's semi-autonomous status. Water supply planning would become an integral part of the City's general planning function. Moreover, all of the advantages discussed in Chapter 5 that accrue to the combined operation of water supply and sewerage systems could be expected to result from the integration of the water supply with waste water disposal functions under the Department of Public Works. These advantages include substantially increased efficiency in administration (including data processing), operations and engineering in addition to the improved coordination of public works activities.

Another consideration in returning the water supply system to direct municipal control is that such a change would be relatively simple. The City Council would have to pass a resolution mandating the change, and the electorate would have to approve it at the polls. The seven member Board of Water Supply need not be eliminated. It would serve in an advisory capacity. In order to advise the City effectively on the administration of the water supply system, the members should be selected on the basis of specific expertise in engineering, planning, finance, law and administration.

Several arguments could be advanced against changing the Board's semi-autonomous status. One line of thought might be that the Board has done an outstanding job over the years as a semi-autonomous agency. In view of this success, why change the Board's status? If there are shortcomings at the Board, and reform is needed, why would it be necessary to change the Board's status while making these reforms? Another line of thought might be that to return the water supply function to the City could inject undue political influence into water supply functions. In the opinion of the writer this last supposition is especially naive because it ignores the fact that political considerations have always played a role in key Board of Water Supply decisions. The crucial questions are whether, or not, a political consideration benefits the public, and whether, or not, it increases the accountability and efficiency of the water supply system.

As far as a Statewide institutional response to water resource needs is concerned, the writer proposes the establishment of a State Environmental Protection Commission and a Department of Environmental Protection to serve as the administrative arm of the Commission.

The Commission would be granted the following authority:

1. To regulate the conservation and development of ground water resources throughout the State.
2. To regulate waste water disposal, and to provide, in cooperation with the Federal Government and the County governments, for the planning, development, construction and operation of sewage treatment plants.
3. To control air, water, noise, solid waste and any other type of environmental pollution found in the State of Hawaii.
4. To coordinate, with the cooperation of the Counties, a Statewide response to the closely related problems of water resource management, waste water disposal and pollution control.
5. To coordinate the State's water resource management, waste water disposal and pollution control activities with the Federal government research and financial assistance programs in these fields.
6. To coordinate a Statewide research effort through the cooperation of the Counties, the University of Hawaii, and other public and private agencies intended to improve water resource management, waste water disposal and the protection of the environment throughout the State.

The county water departments and boards of water supply would retain the operational control of their respective water supply systems. The writer recognizes that the non-contiguous character of the Island-counties provides Hawaii with the geographic potential for effective home-rule administration of municipal services. The State Environmental Protection Commission, and the Department of Environmental Protection, would deal with Statewide water resources concerns:

1. The acquisition of Federal and State support for water resources research and development throughout the State of Hawaii.
2. The coordination of Federal, State and County water resources activities.
3. The coordination of water-related planning, research and development within the State of Hawaii. Water-resource technology (desalting, recycling, impounding, etc.) is a special concern here. A combined agency could be especially effective in the field of waste water reclamation and recycling.
4. In the field of water resources allocation, the Commission would provide a forum for the settlement of differences among the State's municipal, agricultural, industrial and military water users.
5. The Commission would design and implement a comprehensive program for the conservation and development of the State's water resources.

The increasing demand on Hawaii's finite water resources, and the close relationship among water resources management, waste water disposal and pollution control requires the establishment of a State Environmental Protection Commission. The success of the Commission would depend upon the active participation of the counties. In order to provide for this active participation, the writer proposes the establishment of an Environmental Protection Board in each of the four counties. The members of these boards would be selected by the Mayor of each county on the basis of specific expertise in one of the following fields: engineering, law, planning, finance-accounting and administration. The members of these County Environmental Protection Boards would be charged with the dual responsibility of communicating the needs and capabilities of individuals and entities in their community to the State Environmental Protection Commission, and coordinating their County's environmental protection effort with the State's program.

The writer offers the following suggestions for the composition of the County Boards and the State Commission as a springboard for further discussion. Each County Environmental Protection Board would consist of five members appointed by the Mayor of the County to staggered five year terms. The Mayor of each County would designate the Chairman from among the five appointed members. In addition, the Manager of the County Water Department or Board of Water Supply, and the County's Director of Public Works, would serve on the County Environmental Protection Board as ex-officio members with voting rights.

The Chairman of the County Board would represent the County as a voting member of the State Environmental Protection Commission. In addition, the Manager of the County

Water Supply Agency and the County Director of Public Works would represent the County on the State Commission as non-voting, ex-officio members. Thus each of the four counties would provide a voting member, and two non-voting, ex-officio members to the State Commission.

The Governor would appoint five additional voting members to the Commission, and would select the Chairman from among these five. In addition, the following State officials would serve on the Commission in a non-voting, ex-officio capacity:

The Chairman of the Board of Land and Natural Resources.

The Director of the Department of Planning and Economic Development.

The Director of Health.

And The Director of Transportation.

The composition of the State Commission could be shown as follows:

	Voting Members	Ex-officio Members
From the Counties:	4	8
From the State:	5	4
Total:	9	12

An initial impression might be that the number of members, particularly the number of ex-officio members, is too large. But there are reasons for including 12 ex-officio members on the Commission. The Commission is concerned with the coordination of water resources management, waste disposal and environmental protection. The technical expertise of the County water supply agency Managers and the Directors of Public Works is essential to achieving effective coordination. The Directors of Public Works, for example, will be able to provide valuable technical information and practical experience in the areas of sewerage systems, waste water recycling, refuse collection, solid waste disposal and incineration.

The same requirements, the need for technical expertise and for a fully coordinated approach to water resources, waste disposal and environmental protection, are the justification for including the four State level, ex-officio members on the Commission. The 12 ex-officio members would constitute a Technical Advisory Board serving as an adjunct to the Environmental Protection Commission. The Technical Advisory Board would meet separately to consider the facts relating to water resource, waste disposal and environmental protection matters, and would present their findings and recommendations to the Commission as a whole.

In its relations with the Department of Environmental Protection, the Commission would have the responsibility to formulate policy, to establish rules and regulations, to hear appeals and to advise the Director of the Department.

The Department of Environmental Protection would be a full-fledged Department of the State Government. The Director would be appointed by the Governor, and would have Cabinet status. As described earlier in this chapter, the

Commission and the Department would be granted extensive regulatory authority in the areas of water resources, waste disposal and environmental protection.

Details of the composition of the County Boards and the State Commission are presented here simply as a basis for discussion. Nonetheless, certain principles should be maintained throughout the institutional structure: the desirability of active participation by the counties, the desirability of specific expertise at both the County and the State level, and the need for a coordinated approach to solving water resource, waste water and environmental problems.

In order to form a State Environmental Protection Commission, with an effective administrative arm, at least three State agencies, the Department of Land and Natural Resources, the Department of Health, and the Office of Environmental Quality Control, would be required to relinquish certain powers and functions. The Department of Land and Natural Resources would relinquish its authority under the following Chapters of the Hawaii Revised Statutes:

Ch. 174, Water and Land Development.

Ch. 175, Molokai Irrigation and Water Utilization Project.

Ch. 176, Water Resources.

Ch. 177, Ground Water Use.

Ch. 178, Artesian Wells.

Ch. 179, Flood Control and Flood Water Conservation.

Ch. 180, Soil and Water Conservation Districts.

Ch. 183, Forest Reservations, Water Development, Zoning.

The Department of Health would relinquish its authority under the following two Chapters:

Ch. 328A, Furnishing Potable Water.

Ch. 342, Environmental Quality (this key Chapter provides for the regulation of air pollution, water pollution, noise pollution and solid waste pollution, moreover, Ch. 342 establishes the Department of Health as the State agency enforcing the Federal Water Pollution Control Act, Public Law 92-500).

The Office of Environmental Quality Control would relinquish its authority under Ch. 341, Environmental Quality Control.

In effect, the proposed Department of Environmental Protection would assume the responsibilities of the folowing agencies:

1. Water and Land Development Division, Department of Land and Natural Resources.
2. Environmental Protection and Health Services Division, Department of Health.
3. Office of Environmental Quality Control, Office of the Governor.

The staffs of these three agencies would form the administrative backbone of the Department of Environmental Protection.

In the past several years our society has come to recognize the existence of environmental limits. Water is an immensely vital resource; yet we are approaching the time when our ground water supplies will be fully utilized. Long before that point is reached we must prepare institutionally and technologically to supplement the natural supply of fresh water. In this context, waste water should be seen as a potential supplementary water resource. The Federal Water Pollution Control Act of 1972 (P.L. 92-500) recognizes the water resource potential of waste water, and it requires that sewage treatment plants built with Federal assistance under P.L. 92-500 have a potential recycling capability. On one hand, water supply and waste water treatment are intimately related. On the other hand, waste water disposal is bound up with the problems of maintaining environmental quality. The establishment of a State Environmental Protection Commission will provide a continuous institutional response to the closely related challenges of water resource management, waste water disposal and environmental protection.

Consider the case of a hypothetical stream in our State. It is fed by runoff from higher elevations and by ground water seeping and surging to the surface. Along its course, some of its water returns to the ground (and quite probably to the basal fresh water lens); and its surface waters eventually run off to the sea. The stream contributes to our vital ground water supply. If the State builds a dam across part of the stream and diverts some of its waters into a tunnel into the volcanic strata, we increase the stream's contribution to our ground water resources. At another point along the stream, an agricultural or industrial enterprise essential to the economic well-being of perhaps hundreds of people may periodically, or continuously, discharge pollutants into the stream. Federal regulations seek the eventual elimination of this kind of pollution, yet the industry may honestly maintain that in order to eliminate this discharge, they will have to abandon their operation.

Further downstream, an agricultural enterprise may have been drawing irrigation waters from the stream for decades. Clearly that enterprise has an interest in making sure that the State's diversion dam does not deprive its fields of an ample supply of water for irrigation. Moreover, the agricultural enterprise has a valid interest in assuring that the farm or industry discharging pollutants upstream does not jeopardize the quality of its irrigation water.

Still further downstream, swimmers and fishermen have a vital interest in the quality and the quantity of the water in the stream. How can these legitimate, but sometimes conflicting interests, be reconciled for the over all well-being of the community? Clearly, a good deal of discussion and negotiation and compromise is necessary if we are to achieve an equitable and beneficial solution to the problems involved in allocating increasingly scarce water resources. The best institutional setting for the solution of allocation problems is an institutional setting that recognizes the interrelatedness of water resource management, waste water disposal and environmental protection problems. That is one of the reasons why the writer is proposing the establishment of a combined Statewide Environmental Protection Agency.

Let us consider another example. The desalination of salt and/or brackish water is one of the technological methods Hawaii may employ to augment natural ground water supplies. Since the natural supply is finite, all classes of water users, industrial, agricultural and domestic are likely to benefit from the fresh water increment provided by a desalination facility. But the allocation of the desalted water may require negotiations and agreement among several industrial, agricultural, military and municipal water users.

In order to increase the quality of the waters produced by desalination, it is necessary to increase the costs of production. Yet industrial users may require a relatively low quality product (for cooling), agriculture may need a somewhat higher quality product (for irrigation), and municipal water supply systems are likely to require a high quality product for domestic use. How shall these production and allocation decisions be made? How shall the costs be distributed? The writer suggests that the optimum institutional framework in which to make these decisions is a combined Statewide regulatory authority possessing a complete grasp of the local and Statewide water resources situation, and having a thorough and sympathetic understanding of the legitimate needs of industry, agriculture, military and municipal users.

There are two different kinds of costs involved: the financial costs of planning, building and operating the desalination facility (to be born by some combination of Federal, State, municipal and private funding), and the environmental cost to the community. Desalting requires energy, and one form of waste energy, heat, may be removed from the process by discharging coolant waters into receiving waters nearby. Thermal pollution has a detrimental effect on the ecology of the receiving water. The legitimate interests of swimmers and fishermen may be adversely affected. Moreover, the Federal Environmental Protection Agency can be expected to enforce increasingly stringent regulations against thermal pollution.

Desalination produces another kind of undesirable by-product: salt. It may be possible to establish a market for some of the mineral by-products of desalination. But it will be difficult to dispose of most of the considerable quantities of brine produced in desalination without some environmental trade-offs. Federal Environmental Protection Authorities will be increasingly reluctant to permit the discharge of the brine back into the ocean. And municipal water supply authorities can be expected to react negatively to any plan to dispose of brine by digging tunnels and injecting the unwanted material into the earth. Such a practice would probably cause damage to the subterranean fresh water lens. How can the legitimate, but occasionally conflicting interests of the Federal government, State government, municipal governments, industry, agriculture and private citizens be reconciled? The best forum for the reconciliation of these diverse interests is a Statewide agency with the authority to regulate water resources, waste water disposal and environmental quality for the over all well-being of the people of Hawaii.

In order to obtain evaluation of the State Environmental Protection Commission proposed in these pages, the writer provided the Manager and Chief Engineer of the Board of Water Supply, and the Manager and Chief Engineer of the Division of Water and Land Development with a copy of the proposal. Mr. Edward Hirata of the Board of Water Supply responded favorably to the establishment of a State agency to administer all programs relating to air, water, solid waste and noise pollution. But Mr. Hirata expressed the following reservations:

1. The 21 member Environmental Protection Commission would prove too unwieldy to provide effective leadership.
2. Authority and responsibility should reside with the chief executive of the Department of Environmental Protection.

3. The authority for implementing environmental programs should be granted explicitly to the counties.[7]

Mr. Robert T. Chuck of the Division of Water and Land Development, Department of Land and Natural Resources, responded as follows:

> The concept of the establishment of a State Environmental Protection Agency that would coordinate and control water resources, waste water disposal, pollution control activities, and State-wide research in these efforts, I think, is a good idea. In my association with many mainland organizations in the field of water resources, I have found more and more a trend towards combining water quantity with water quality (i.e., that of placing under one administrative umbrella water resources, waste water disposal, and pollution control activities). I felt that eventually Hawaii would, at the right time, combine its activities in these fields.[8]

Mr. Chuck's chief reservation involved the size of the membership of the Commission:

> The Commission setup of having 21 members seems a little too bulky even though there will be only 9 voting members. I know that you have addressed yourself to this problem in your paper and have explained why you are proposing this wide representation. But experience has shown that if such boards and/or commissions are too large, they become cumbersome and when members have no vote they lose interest and the board sometimes becomes ineffective.[9]

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[7] Edward Y. Hirata, letter to the writer on the subject of the proposed State Environmental Protection Commission, February 6, 1975.

[8] Robert T. Chuck, letter to the writer on the subject of the proposed State Environmental Protection Commission, February 26, 1975.

[9] Ibid.

In November, 1974, the writer requested information from Mr. Brevard Crihfield, Executive Director of the Council of State Governments, on the status of combined water resources and environmental protection agencies nationwide. Mr. Crihfield informed the writer that the Council of State Governments is conducting research in the same field, and provided a list of eight states believed likely to have a combined authority. A questionnaire was devised and mailed to the appropriate agency in each of the eight states. At this writing, six of the state agencies have responded to the questionnaire:

Georgia, Department of Environmental Protection,

Illinois, Environmental Protection Agency,

New Hampshire, Water Supply and Pollution Control Commission,

Ohio, Environmental Protection Agency,

Pennsylvania, Department of Environmental Resources,

South Dakota, Department of Environmental Protection.

Since a field of only eight agencies was surveyed, conclusive results were not expected. The survey was simply a preliminary means of obtaining information on the practical advantages (or lack of advantages) of State Environmental Protection Agencies. Virtually every research effort uncovers a certain amount of ambiguous information, and the information gathered from this questionnaire was not an exception. For example, the Illinois Environmental Protection Agency does not consider itself a combined agency, although Chapter III½ of the Illinois Annotated Statutes establishes the Agency, and a Pollution Control Board, and states as follows:

> It is necessary to establish a state-wide program for environmental protection and to cooperate fully with other States and with the United States in protecting the environment; . . . air, water and other resource pollution, public water supply, solid waste disposal, noise and other environmental problems are closely inter-related and must be dealt with as a unified whole in order to safeguard the environment. . . .[10]

In the cases of the combined agencies serving Pennsylvania and South Dakota, officials are awaiting the implementation of existing legislation. In New Hampshire, additional regulatory authority is under discussion, but has not yet been submitted to the Legislature. This situation is understandable because these States and others are in the process of responding to the provisions of the Federal Water Pollution Control Act of 1972 which encourages a unified response to water resource management, waste water disposal and environmental protection.[11]

The results of the questionnaire are as follows:

Question 1: Does your agency have regulatory authority over ground water?

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[10] Illinois, Annotated Statutes, Chapter III½. Section 1002 through 1013.

[11] Based on a reading of documents provided by the six agencies responding to the survey, the writer believes that Pennsylvania is emerging as the leader in the environmental protection field.

Replies:	All agencies answered affirmatively except South Dakota, which is awaiting the implementation of existing legislation, and Illinois, which has regulatory authority only in emergency situations.
Question 2:	Does your agency have responsibility for enforcing the provisions of the Federal Water Pollution Control Act (PL 92-500)?
Replies:	All affirmative, with Pennsylvania expecting implementation in March, 1975.
Question 3:	Does your agency administer the National Pollutant Discharge Elimination System (NPDES) permit system?
Replies:	Georgia, New Hampshire and Ohio replied affirmatively. Pennsylvania and Illinois are awaiting implementation. South Dakota has elected not to participate in the optional NPDES permit system established by the Federal Water Pollution Control Act.
Question 4:	Does your agency participate in the State Continuing Planning Process described in PL 92-500?
Replies:	All affirmative, with Illinois expecting implementation.
Question 5:	Has the existence of a combined regulatory agency contributed to effective enforcement of PL 92-500?
Replies:	New Hampshire, Ohio and South Dakota replied affirmatively. Pennsylvania is anticipating affirmative results. Georgia and Illinois replied negatively. Affirmative: 4 Negative: 2
Question 6:	Has the existence of a combined regulatory agency in your State contributed to the coordination of water

resource/waste water planning and project development?

Replies: All affirmative except Illinois.

Affirmative: 5
Negative: 1

Question 7: Has the existence of a combined regulatory agency helped municipalities in your State obtain Federal funding for sewage treatment plants under PL 92-500?

Replies: Ohio and Pennsylvania replied affirmatively. Georgia and Illinois replied negatively. New Hampshire and South Dakota did not express an opinion.

Affirmative: 2
Negative: 2
No Opinion: 2

Question 8: In view of your experience, is it preferable to lodge the regulation of water resources, waste water disposal and environmental protection in a single State agency, or in separate agencies?

Replies: Ohio, Pennsylvania and South Dakota replied in favor of a combined agency. New Hampshire and Illinois replied in favor of separate agencies. Georgia's reply was ambiguous.

For single agency: 3
For separate agencies: 2
Uncertain: 1

Question 9: In general, how would you describe your agency's relations with municipalities?

Replies: All affirmative in varying degrees. Replies stressed interdependence and cooperative, constructive relationships.

Question 10: What do you see as the major challenge(s) facing your agency in the next several years?

Replies:

a. Four of the six agencies cited the need to improve water quality (especially the quality of drinking water) as a major challenge.

b. Four of the agencies cited the need to obtain the State and Federal funding necessary to implement programs and enforce statutes and regulations.

c. Three of the agencies pointed to the training of municipal officials and operators as a major challenge. The respondents expressed concern that municipal officials were insufficiently aware of their responsibilities with respect to water resource conservation and environmental protection.

Although the survey did not yield conclusive results, it succeeded in providing information on a subject about which very little is known: the practical (not simply theoretical) advantages of State Environmental Protection Agencies. Little is known on the subject because such agencies have come into existence only recently as certain States have responded to the passage of Federal environmental legislation during the past few years.

The survey was successful in another respect: the letters accompanying the questionnaires and the letters accompanying the replies opened communication between the Honolulu Board of Water Supply and water resource managers working in combined State agencies on the mainland. The following excerpt from the reply written by Walter A. Lyon, Director of the Bureau of Water Quality Management, Pennsylvania Department of Environmental Resources is an example:

> Since we seem to have many common interests in the field of harmonizing all aspects of water management in a single organization, we would certainly be pleased to have you, or your representatives visit us here in Harrisburg.[12]

The writer intends to maintain contact with the Council of State Governments and the six State Environmental Protection Agencies and request information, from time to time, on the success of their programs. Moreover, the writer plans to review the proposals made in this chapter concerning the establishment of an Environmental Protection Agency for the State of Hawaii. The writer may, for example, reconsider the number of members of the proposed Commission.

The writer is convinced of the value of a combined State regulatory agency for water resource management, waste water disposal and environmental protection, and intends to present the proposal described in this chapter (together with strong supporting evidence) to the 1976 Session of the Hawaii Legislature for possible enactment into law. With this purpose in mind, the next four chapters are concerned with technological means of extending Oahu's water resources.

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[12] Walter A. Lyon, letter to the writer on the subject of State Environmental Protection Agencies, January 3, 1975.

Chapter 7

DESALINATION

Four areas of scientific inquiry and technological application are particularly relevant for Oahu's future water supply needs. The desalination of sea water and brackish water, the recycling of waste water, resource conservation and energy constitute the four major areas of research; and the next four chapters of this dissertation will consider each of them.

At the present time, there are over 800 desalting plants of 25,000 gallons per day capacity, or larger, in operation or under construction throughout the world. These facilities have a combined capacity of about 450 million gallons per day. Yet this figure is not so impressive when one considers that the Honolulu Board of Water Supply supplies about 120 million gallons per day to Oahu alone. Nonetheless, the application of desalting technology is expanding at a rate that will double, or triple, present production by 1980.[1]

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[1] United States Department of the Interior, 1972-1973 Saline Water Conversion Summary Report (Washington, D.C.: Office of Saline Water, 1973), p. ii.

The largest desalting facility in the Western Hemisphere is the 7.5 mgpd plant at Rosarita Beach, which serves the City of Tijuana in Baja California. The largest installations in the U.S. are the 2.6 mgpd plant serving Key West, and the 1.5 mgpd unit providing water to Siesta Key, Florida. Plants with a capacity of up to 40 mgpd are recognized as a practical solution to water supply needs in many parts of the world.[2]

The purpose of desalination is to improve water quality by removing dissolved salts. Desalting processes may be divided into two broad categories: methods which require water to undergo a phase change during the desalination process, and those methods which separate water and salt molecules within the liquid phase. Phase change methods include distillation, either by the multistage flash (MSF) process, or by vertical tube evaporation (VTE), and freezing. In distillation, water must undergo a change in phase from liquid to vapor in order to separate it from dissolved salts. Water vapor is then condensed back into liquid for storage and distribution. One characteristic of distillation is the large amount of energy required to vaporize the water. The MSF and VTE processes are designed to recover some of this thermal energy for re-use on incoming water.[3]

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[2] Water Desalting Committee, American Water Works Association, "A 1972 Overview of Desalting," Journal of American Water Works Association (November, 1972), pp. 690-693. According to the Desalting Plants Inventory Report No. 4, published by the U.S. Department of the Interior, Office of Saline Water in 1973, there are four desalting plants at Curacao, Netherlands Antillies, with a combined capacity of 8.2 mgpd. The largest of these plants has a capacity of 3.44 mgpd. The largest desalting plant in the world is located in Kuwait. Its capacity is 25.2 mgpd.

Freezing, or vacuum freeze-vapor compression (VF-VC), is a second phase change approach to desalting. This process relies on the fact that as water freezes and ice crystals are formed in solution, dissolved salts remain behind in solution. It becomes possible to produce fresh water by removing the ice crystals from solution and melting them. Freezing has an important advantage over distillation in that scale formation and corrosion are much less serious problems in VF-VC than in MSF and VTE. However, with present technology, the energy required to operate the freezing process is higher than the energy required for distillation, nonetheless, VF-VC freezing plants with capacities of 100,000 mgpd are being built, and technological advances in several stages of the process indicate a bright future for desalination by freezing.[4]

Both phase change processes, distillation and freezing, are most suitable for the desalting of waters that have a high content of dissolved salts, sea water for example. At the present time, brackish waters can be desalted at less expense by using one of the single phase processes: electrodialysis, reverse osmosis and ion exchange.[5]

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[3] J. M. Duncan and B. J. Garrick, Water Desalting in Hawaii (Honolulu, Hawaii: Holmes and Narver, Inc. for State of Hawaii, Department of Land and Natural Resources and U.S. Department of the Interior, Office of Saline Water, 1974), p. 21.

[4] Ibid., pp. 21, 23.

Water remains in the liquid phase during the single phase processes. Thus, at the outset, there is a considerable advantage in terms of energy utilization over distillation and freezing. Electrodialysis and reverse osmosis, two processes that depend on the use of semi-permeable membranes, have been shown to be technically and economically feasible for the desalination of brackish waters. Using the standard measurement of Total Dissolved Solids (TDS) it is possible to consider four water quality levels:

1. High quality potable water: 100 to 250 parts TDS per million parts of water. (The drinking water provided by the Honolulu Board of Water Supply contains about 100 ppm TDS.)
2. Minimum Quality potable water: 500 ppm TDS.
3. Brackish water: 500 to 10,000 ppm TDS. (These are the waters best suited for desalination by single phase processes.)
4. Sea water: about 35,000 ppm TDS. (Distillation and freezing, the phase change processes, are more suitable for desalting waters with high concentrations of TDS.)

In electrodialysis, electrical energy is used to drive dissolved ionized solids through semi-permeable membranes. Positive and Negative membrane pairs are arranged in series and stacked in various configurations in order to achieve the desired degree of purity in the product waters. The two major operating maintenance expenses in electrodialysis are electric power and membrane replacement. Research efforts have been directed toward improving the operating characteristics and durability of membranes, and increasing the over all efficiency of the equipment involved in the process.[6]

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[5] American Water Works Association, Desalting Techniques for Water Supply Quality Improvement (American Water Works Association, Research Foundation, for U.S. Department of the Interior, Office of Saline Water, 1973), p. 55.

Reverse osmosis depends upon the following process:

> When two solutions of different concentrations are separated by a semi-permeable membrane, water from the less concentrated solution diffuses through the membrane to the more concentrated solution in an effort to equalize the concentrations. This natural phenomenon is called osmosis and has been observed for thousands of years. Both animal and plant life are dependent upon osmosis for fluid transfer from cell to cell. During osmosis the volume of the more concentrated solution will increase with a resulting pressure increase. This pressure is called osmotic pressure. If the more concentrated solution is subjected to a pressure greater than the osmotic pressure, water molecules will diffuse through the semi-permeable membrane to the less concentrated solution. The direction of diffusion is opposite to normal. Thus the operation is called reverse osmosis.[7]

The feasibility of reverse osmosis as a desalting technique depended on the development and production of a membrane with the following characteristics:

1. The membrane must prevent the passage of practically all of the dissolved salts present at the interface between the membrane and the water under treatment.

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[6] Water Desalting in Hawaii, pp. 23-26; Desalting Techniques for Water Supply Quality Improvement, pp. 56-58.

[7] Desalting Techniques for Water Supply Quality Improvement, p. 61.

2. The membrane must maintain its operating efficiency over long periods of time without becoming compacted and fouled by scale and contaminants.

3. It must be low in cost.[8]

The research situation with regard to reverse osmosis is especially favorable. Recent advances in membrane technology have led the Office of Saline Waters to conduct extensive studies with this process. Reverse osmosis has become an established process for desalting brackish waters up to 10,000 ppm TDS, and progress is being made toward developing osmotic membranes with the capability of desalting sea water.[9] As far as operating costs are concerned, the major factor is the electrical power needed for pumping the feed waters through the modules in which the reverse osmosis process takes place.[10]

In the ion exchange process, the stream of feed waters is brought into contact with an exchange material, usually a synthetic resin. Undesirable salt ions from the solution are exchanged with acceptable ions from the resin. Ion exchange processes are capable of either softening water by removing calcium and magnesium ions in favor of sodium ions, or removing salts entirely by replacing salt ions with positive and negative ions that combine to make water. Resins are normally recycled by regenerating them through appropriate chemical treatment.

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[8] Harry A. Faber, Sidney A. Bresler and Graham Walton, "Improving Community Water Supplies with Desalting Technology," Journal of the American Water Works Association (November, 1972), pp. 705-710.

[9] "A 1972 Overview of Desalting," p. 693.

[10] Water Desalting in Hawaii, p. 31.

Most of the ion exchange systems in operation today produce a high quality water for laboratory and industrial use. Only limited applications of the ion exchange process have been made as a desalting process for brackish water. The chief reason why the process has been used so infrequently by municipal water supply systems is the high cost of the chemicals necessary to regenerate the ion exchange resins. Since the amount of regenerants is proportional to the amount of dissolved salts removed, ion exchange is limited to the demineralization of waters of relatively low salinity. Nevertheless, there are some real advantages to the process: ion exchange is a comparatively simple process, capital investments are relatively low, there are fewer mechanical difficulties than with other desalting techniques, and as with electrodialysis and reverse osmosis, corrosion is only a minor problem.[11]

As the Honolulu Board of Water Supply considers the feasibility of using desalting techniques to improve the quantity and quality of the water it supplies to its customers, the Board should evaluate all five of the major desalting processes. Table 1 indicates the complexity of the considerations involved in selecting the most desirable process for a given location.

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[11] Maurice A. Lynch, and Milton S. Mintz, "Membrane and Ion Exchange Processes--A Review," Journal of the American Water Works Association (November, 1972), pp. 711-725; Water Desalting in Hawaii, pp. 31-33; Desalting Techniques for Water Supply Quality Improvement, pp. 59-60.

In December, 1969, the Honolulu Board of Water Supply authorized the firm of Burns and Roe, Inc. to determine the feasibility of dual purpose desalting plants on Oahu. The dual purpose plant envisioned by Burns and Roe would be located at Kahe Point, Oahu, and be in production by 1991. The Hawaiian Electric Company would own and operate the power generating facilities. Hawaiian Electric would produce power for public consumption and sell steam and power to an adjacent desalting plant owned and operated by the Board of Water Supply. The year 1991 was chosen as a target date because Burns and Roe assumed that the demand for fresh water would exceed the natural ground water supply in that year. The desalting plant would be of the multi-stage flash (MSF) type, and it would be designed to demineralize sea water.[12]

Burns and Roe examined four possible applications of dual purpose desalting plants on Oahu. In the first case, a nuclear fueled MSF plant with a capacity of 20 mgpd would go

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[12] Burns and Roe, Inc., Feasibility and Economics of Dual Purpose Power-Desalting Plants (Honolulu, Hawaii: Burns and Roe, Inc., for the Honolulu Board of Water Supply, 1971), pp. 1-4.

TABLE 1

A COMPARISON OF DESALTING METHODS

Consideration	Distillation (D)	Freezing (F)
Stage of Development	Advanced	Early
Design and Construction Period	1-1/2 to 5 yrs.	1-1/2 to 5 yrs.
Removal Capability	High purity product	Separation difficult
Sensitivity to Operating Conditions	Low	Low
Pretreatment	Modest	Very little
Production Rate	Decreased by scaling	Constant
Mechanical Problems	Many	Many
Corrosion	Severe	Minimal
Complexity of System	Medium	Highly complex
Energy Demand	50 to 60 times IX	27 to 35 times IX
Capital Cost	5 to 6 times ED	3 to 4.5 times ED
Cost of Product Water	High: 3 to 5 times ED and RO	Between ED and D

Electrodialysis (ED)	Reverse Osmosis (RO)	Ion Exchange (IX)
10 yrs. experience	5 yrs. experience	Advanced
1 to 2-1/2 yrs.	1 to 2-1/2 yrs.	1 to 2-1/2 yrs
Limited to 50% per pass	Up to 99% per pass, removes organics	Removes all ions
High	Low	Low
Medium	Modest to extensive	Less than ED and RO
Slight decrease with time	Decreases with time	Constant
Some	Some	Very few
Minimal	Minimal	Minimal
Medium	Low	Low
4 to 6 times IX	10 to 12 times IX	Least of all methods
Least of all methods	1.2 to 1.6 times ED	1.6 to 2 times ED
Low	Low	Low

into operation at Kahe Point in 1991. In the second case, fossil fuel would provide the power for a 20 mgpd MSF plant. Burns and Roe pointed out that since Board of Water Supply estimates anticipated an annual increase in the demand for water on the order of three million gallons per day, a 20 mgpd facility would have to be built every six and a half years. Whether powered by nuclear or fossil fuel, a 20 mgpd plant would go into operation in 1991, a second in 1998, and a third would follow in 2006. In case three, a 50 mgpd nuclear powered desalting plant would go into production in 1991. In case four, fossil fuels would provide the energy for a 50 mgpd facility. The first 50 mgpd plant would be ready to go to work in 1991, and a second would follow in 2008 in order to stay ahead of demand.[13]

Burns and Roe used computer techniques to estimate the cost of water produced by each of the four alternatives as follows:

Case 1, nuclear powered, 20 mgpd:
$.85 per 1,000 gallons.

Case 2, fossil fuel powered, 20 mgpd:
.93 per 1,000 gallons.

Case 3, nuclear powered, 50 mgpd:
.75 per 1,000 gallons.

Case 4, fossil fuel powered, 50 mgpd:
.78 per 1,000 gallons.[14]

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[13] Ibid., pp. 12-15.

[14] Ibid., p. 1 and Exhibit 1.

As expected, larger facilities were expected to be more economical than the smaller ones. Somewhat surprisingly, nuclear power plants were judged significantly more economical than conventional power even at 1971 oil prices. Burns and Roe were aware of increasing petroleum prices, and pointed out that such increases would contribute to the attractiveness of the nuclear alternative. It should be noted in this context that the price of petroleum on the world market quadrupled in the eighteen months preceding January, 1975.

Although the Burns and Roe report is only four years old, several factors indicate that the study's usefulness to water resource managers and planners will be quite limited. Inflated construction costs, fuel costs and interest rates have made the report's economic forecasts obsolete. A second problem is that although the report points toward nuclear fuel as the most economically feasible alternative, there is no discussion of the safety hazards involved in the operation of nuclear power plants. Even if the hazards of nuclear fission were minimal, there is still the question of whether the public would accept a nuclear facility on Oahu. Burns and Roe stop short of considering these nuclear-related problems. Moreover, their report is too limited in another important respect: they ignore the potential for desalting brackish water on Oahu, and concentrate on the much more difficult and costly process of desalting sea water. If they had considered the desalting of brackish water, a whole range of lower cost alternatives would have opened up to them.

Finally, Burns and Roe rather naively accept the Board of Water Supply's projection of a constant annual increase of 3 million gallons per day in the demand for fresh water on Oahu. In January, 1975, with the publication of the Second Edition of the 2020 Plan, the Board changes its projection from a constant annual increase of 3 million gallons per day to an annual increase of 6 million gallons per day. The Board expects the demand for fresh water to grow at twice the annual rate anticipated in 1971. Moreover, it is unwise to expect demand to increase at a constant rate over a period of fifty years. There are too many variables involved to expect such a long range forecast to be accurate. Some of these variables are unanticipated, such as an economic decline (the depression of the 1930's was a major factor in reducing the demand for water on Oahu), and war (World War II accelerated demand). Other variables may be the result of conscious decisions by public policy decision makers. For example, the people of Oahu, and decision makers in public life, may come to the conclusion that the quality of life on Oahu, perhaps even the economic well-being of the Island, require measures designed to limit population. If such decisions were made, and if they were implemented successfully, one could reasonably expect some levelling of the demand for fresh water. On the other hand, this community might opt for accelerated growth on Oahu, and that choice would affect the demand on Oahu's water resources. The point is that citizens and public decision makers have a very real ability to affect such fundamental community concerns as water resources and water supply. There is nothing inevitable about a constant annual increase in the demand for water at any particular rate. Burns and Roe should have posed some of these questions in their report instead of proceeding as if an annual increase of 3 mgpd were a foregone conclusion.

In March, 1973, Manager and Chief Engineer, George Yuen, discussed the outlook for desalination at a conference on ocean resources. Mr. Yuen cautioned that desalination would not be an easy answer to Oahu's future water resources problems unless people were willing to pay the high cost of desalting:

> At the present time water development costs on Oahu are slightly less than 10 cents per thousand gallons. Based on present day technology, the cost of desalting (using fossil fuel) exceeds $1.00 per thousand gallons. This does not include the cost of large pumping stations and transmission mains and storage facilities which would be necessary to pump this water from sea level to points of use. The unit cost figure mentioned does not include the cost of land, and that could be an important factor on Oahu. Also, the cost of disposal of brine resulting from the process is probably not included.[15]

Mr. Yuen was more optimistic about the possibility of desalting brackish waters on Oahu. He mentioned that the

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[15] George Yuen, "Water for the Future--Is Desalting the Answer?" address to the Hawaii's Ocean conference, Princess Kaiulani Hotel, Honolulu, Hawaii, March 9, 1973.

Board is taking an inventory of brackish waters, and that current estimates indicate the presence of fifty billion gallons of brackish water in Oahu's natural water storage basins. It was clear from Mr. Yuen's remarks that the desalting of sea water had assumed a low priority in the Board's long range plans. He considered the demineralization of brackish water, the recycling of waste water and the treatment of impounded water to be more attractive alternatives for Oahu's future water supply needs.[16]

In June, 1974, The Department of Land and Natural Resources, State of Hawaii, published a comprehensive report by Holmes and Narver, Inc., entitled Water Desalting in Hawaii. The Holmes and Narver study has a significant advantage over the Burns and Roe study because Holmes and Narver begin with the assumption that it is more economically feasible to desalt brackish water than to desalt sea water. Holmes and Narver concentrate on the Kihei-Makena area of Maui, and the Kiholo area of the Big Island as two regions where growth is anticipated, but water supplies are limited, and the desalting of brackish water could be a realistic means of meeting water supply needs. Although the study does not deal specifically with Oahu, its conclusions are relevant:

1. Desalting brackish water, which is abundantly available in many areas of Hawaii, is more

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[16] Ibid.

economically feasible than desalting ocean water.

2. The desalting of brackish water even at top priority locations is less economical than transporting existing sources, unless the transport distances are very great, or treatment or impounding costs are prohibitively high.

3. The desalting of brackish ground water may be an attractive source of supply for isolated villages or resorts with no fresh water resources and little potential for growth.

4. Due to the advances being made in the technology of electrodialysis and reverse osmosis, rapid increases in power costs and increasing equipment and construction costs, the final selection of a water desalting method should be made at a time reasonably close to the need for construction and should be based on economic evaluation of alternatives and competitive bids for the specific conditions related to the sector under consideration.[17]

Holmes and Narver estimated that electrodialysis would be the least costly method of desalting brackish waters in Hawaii. Costs would range from about $.52 per 1,000 gallons under near ideal conditions to $1.67 depending on the following factors:

1. The quality of the feed waters (costs would tend toward the lower figure provided the feed waters are of relatively high quality, 1,000 ppm TDS, for example).

2. The quality of the product water (it is less costly to produce a minimum quality product water, 500 ppm TDS, than to produce higher quality product waters).

3. The size of the desalting plant and the percentage capacity at which it is operated (lower costs are obtained for large plants,

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[17] Water Desalting in Hawaii, pp. 3, 60.

over 7 mgpd capacity, operating above 75% of capability).[18]

Although the desalination of brackish water offers somewhat more promise than desalting sea water in Hawaii, there may be considerable potential for techniques designed to demineralize waste water effluent as part of a water recycling process. The following chapter will consider the feasibility of water recycling in Oahu.

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[18] Ibid., pp. 59, 60.

Chapter 8

WATER RECYCLING AND TREATMENT

Waste water has become recognized as a potential water resource. This chapter will review waste water reclamation practices that are potentially important for domestic, industrial and agricultural uses on Oahu. As part of the consideration of the domestic applications of water recycling, this chapter will consider water treatment processes, including fluoridation, that are particularly relevant for the Hawaiian Islands.

People use water for drinking, for irrigation, for recreation, for ornamental purposes and among other uses, for transporting wastes. Water that has been used to transport municipal and industrial wastes is still more than 99% water. Its appearance is altered, but its basic structure is unchanged.[1] This water can be recovered and used again. The re-use of the water for the recharge of ground water supplies, for irrigation and for industrial use has been with us for a good number of years. We can expect to see considerably more water re-use by industries and agriculture as waste water becomes more widely recognized as a supplementary water source, and as Federal and State anti-pollution regulations become increasingly stringent. The coming years will also probably see the acceptance of treated waste water as a source of potable water for domestic supplies. At present, there is only one community in the world practicing the direct re-use of waste water for public water supplies: Windhoek, South-West Africa.[2]

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[1] Paul D. Haney, "Water Reuse for Public Supply," Journal of the American Water Works Association (February, 1969), pp. 73-78.

There is, however, a considerable amount of indirect waste water re-use for domestic supplies occurring in the United States. A Federal Water Pollution Control Administration study based on a sample of 155 U.S. cities using surface water supplies found that "the range of up-stream municipal waste water present in the source stream during low flow is from 0 to over 18 percent, with a median, based on population served, of 3.5 percent."[3] In other words, about one gallon in thirty of the sampled cities' potable water supply has passed through the waste water system of an upstream community.

The basic function of waste water treatment is to use physical, chemical and biological means in order to accelerate natural purifying processes. Treatment is intended to remove the following pollutants:

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[2] Daniel A. Okun, "Planning for Water Reuse," pp. 617-622.

[3] L. Koenig, Studies Relating to Market Projections for Advanced Waste Treatment (Washington, D.C.: Federal Water Pollution Control Administration, 1966). The entire publication is relevant in this context.

1. Oxygen demanding wastes (the most common sources are domestic sewage and food processing plants).
2. Pathogenic organisms.
3. Biostimulants and plant nutrients.
4. Synthetic organic chemicals (detergents and pesticides).
5. Inorganic chemicals and other mineral substances.
6. Sediments (sand, soil and other minerals).
7. Floatables (grease, fats and oils from domestic wastes and food processing plants).
8. Thermal and radioactive pollutants, if present.[4]

There are three categories of waste water treatment methods: primary, secondary and advanced. (Note illustrations following this discussion of treatment methods). Primary treatment is designed to physically remove solid material from the waste water. In primary treatment, screens are used to remove rags, sticks and other large floating objects. Grit chambers and sedimentation tanks allow sand and other solids to settle and be removed for disposal and further treatment. The effluent itself may be chlorinated prior to disposal or further treatment.

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[4] Honolulu Board of Water Supply, "Sewage Treatment Plant Operations," Honolulu, 1974. The pages of this report are not numbered. (Mimeographed.)

Secondary treatment is intended to biologically remove organic matter from primary treatment effluent. There are two principal methods: trickling filters, and the activated sludge process. In the trickling filter method, effluent is sprayed on a bed of stones several feet high. Bacteria collect and multiply on the stones and consume organic wastes in the effluent. The biodegraded effluent is collected, allowed to settle in sedimentation tanks, and may be chlorinated for disposal or further treatment. In the activated sludge process, waste water, bacteria and air are mixed in an aerator. During aeration, bacteria break down the organic matter. The effluent proceeds to a sedimentation tank, and the settled sludge, which is rich in bacteria, is returned to the aeration tank to facilitate the digestion of sewage.

Communities occasionally make use of lagoons, stabilization ponds and oxidation ponds to retain sewage in a holding area. Oxygen, bacteria, sunlight and algae operate symbiotically to restore waste water to a quality similar to secondary treatment. One problem with oxidation ponds is that they require a relatively extensive land area. In addition, the pond may give off an unpleasant odor. People living near the oxidation pond at Waipahu, Oahu, complained frequently about the facility until it was upgraded by the addition of an aerator.[5]

Advanced waste treatment methods use combinations of physical and chemical techniques such as coagulation-sedimentation, adsorption, electrodialysis and reverse osmosis to upgrade water quality and meet stringent Federal anti-pollution regulations. In the coagulation-sedimentation process, alum, lime or iron salts are added to the waste water solution in order to bond with particles in the effluent, increase their weight, and speed up the settling process. Adsorption removes refractory organics that cause foaming, taste and odor problems. In this process, waste water is filtered through activated carbon. A variety of undesirable particles adhere to the porous surface of the carbon filters; the effluent is purified, and the carbon can be regenerated for re-use. Electrodialysis and reverse osmosis techniques (described in Chapter 7) may be used to remove dissolved salts from the waste water.

It is possible to combine several treatment methods in order to meet water quality requirements. Equipment may be placed in series: primary treatment to remove some solids, secondary treatment to remove most of the organic material, coagulation-sedimentation to remove most of the suspended solids, carbon adsorption to eliminate remaining dissolved organic material, electrodialysis or reverse osmosis to extract dissolved salts, and chlorination to disinfect the effluent. In other cases, after primary and secondary treatment, the effluent may be divided into two streams, one to pass through coagulation-sedimentation and adsorption, the other through demineralization. Then the effluent streams can be re-combined when they have reached the desired level of treatment.[6]

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[5] Honolulu Board of Water Supply, "Notes on Waste Water Treatment for Public Presentation," Honolulu, 1974. The pages are not numbered. The entire presentation is relevant in this context. (Mimeographed.)

Illustrations 2 through 7 on the following pages depict waste water treatment methods.

The Federal government has recognized that contemporary industrial civilization is generating pollutants that are not only damaging to receiving waters, but are practically overwhelming many of them. Refractory organics, nutrients, suspended solids and inorganic salts are placing such a burden on the nation's sewerage treatment facilities, that primary and secondary treatment are frequently inadequate to maintain acceptable conditions in receiving waters. Since so many of the nation's lakes and streams are sources of municipal water supplies, a degradation of water quality in streams and lakes reduces the fitness of the water resources available to meet municipal needs. In this context,

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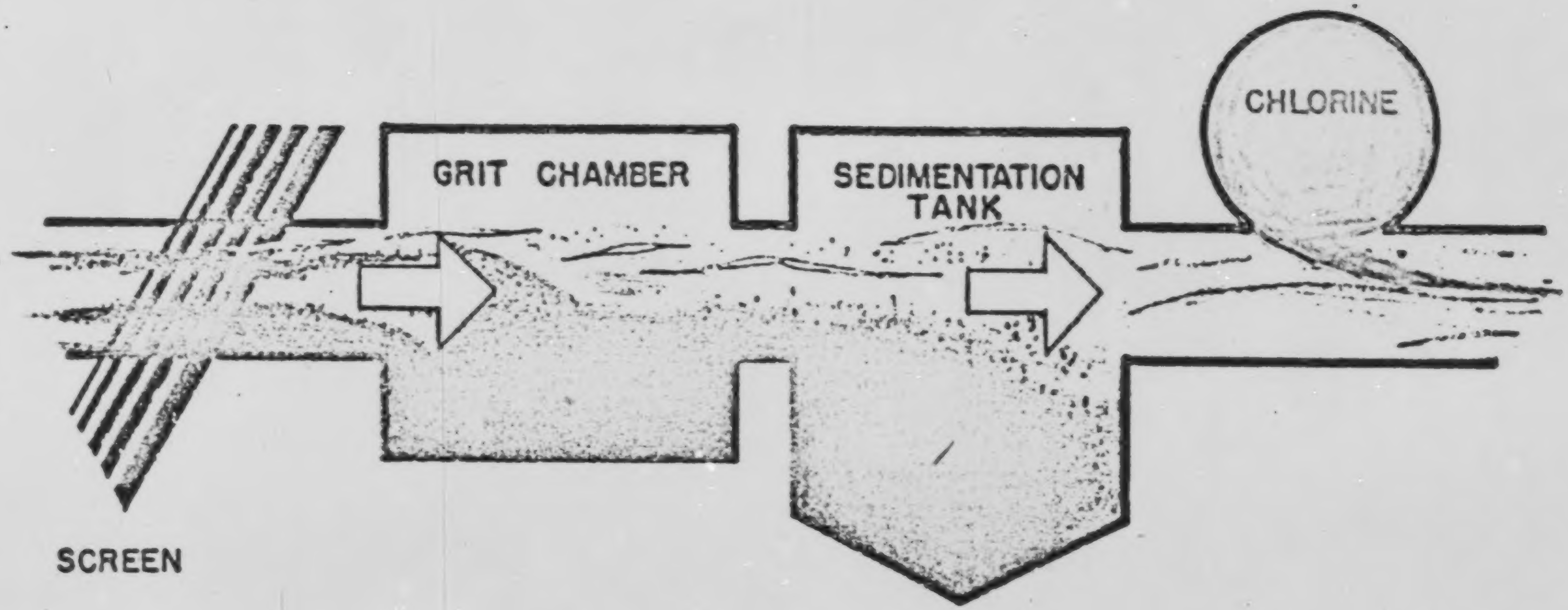
[6] Ibid.

ILLUSTRATION 2

PRIMARY TREATMENT

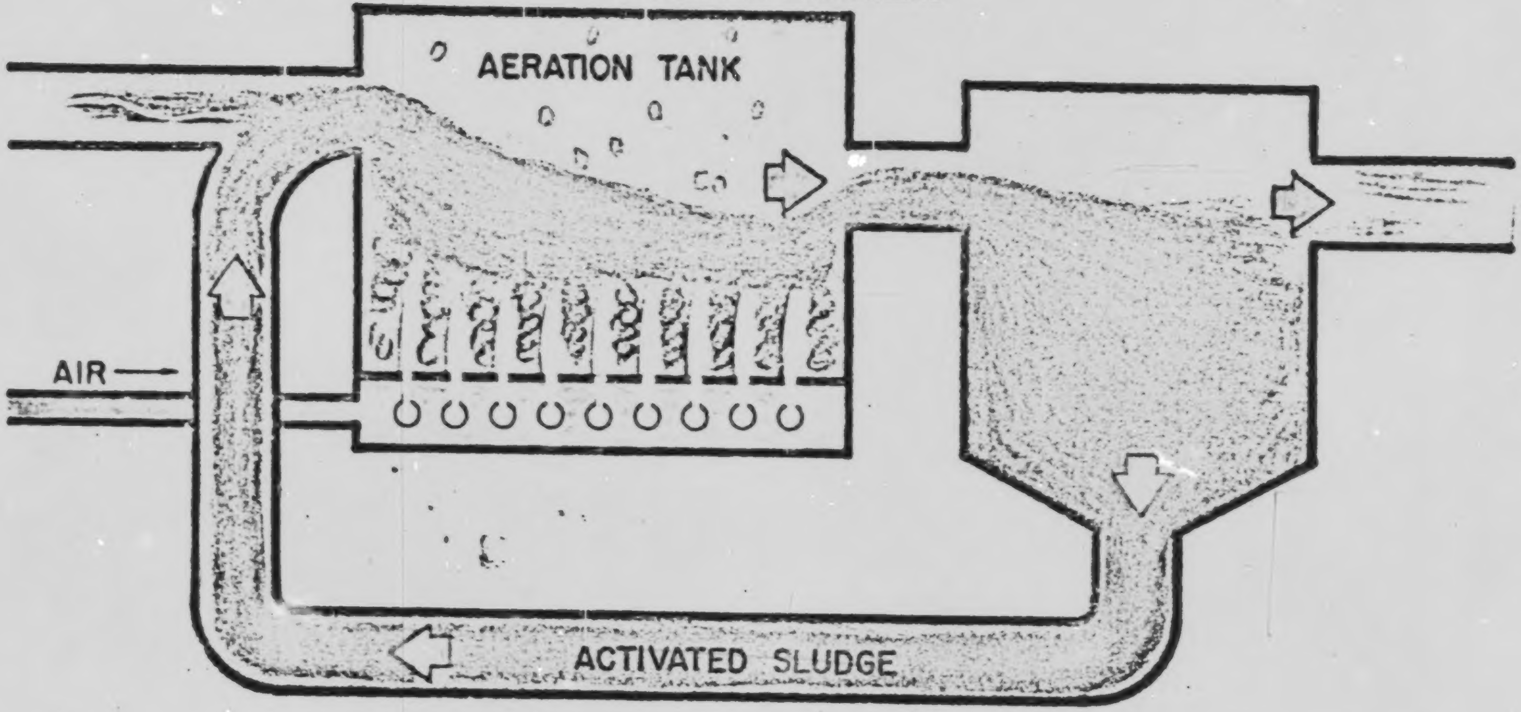

GRIT CHAMBER
SEDIMENTATION TANK
CHLORINE
SCREEN

PRIMARY TREATMENT

Primary treatment is designed to physically remove solid material from the waste water. Screens are used to remove rags, sticks and other large floating objects. Grit chambers and sedimentation tanks allow sand and other solids to settle and be removed for disposal.

ILLUSTRATION 3

SECONDARY TREATMENT

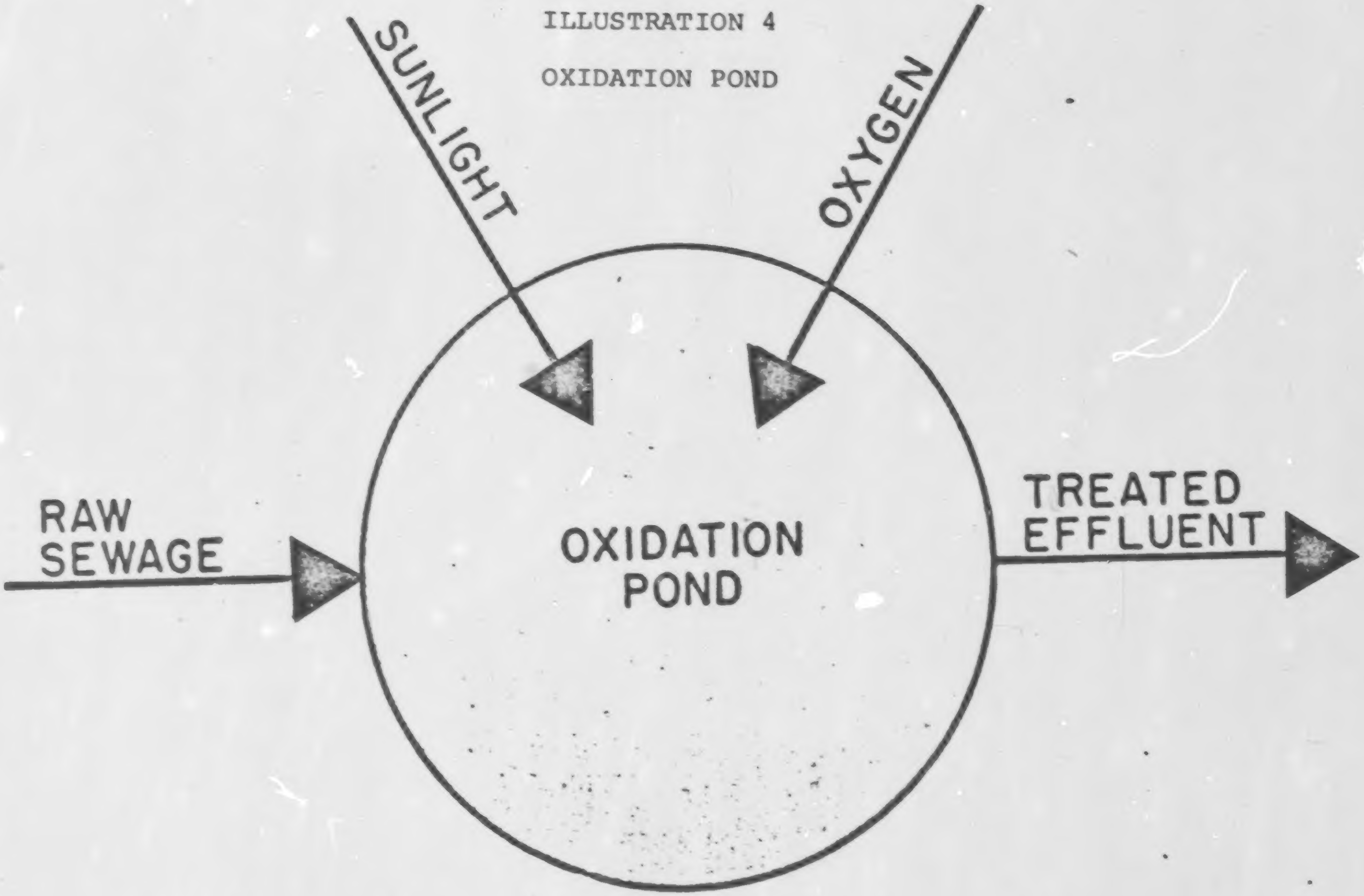


SECONDARY TREATMENT

Secondary treatment is designed to biologically remove organic matter from primary treatment effluent. In the activated sludge process pictured above, waste water, bacteria and air are mixed in an aerator. During aeration, bacteria break down the organic matter.

ILLUSTRATION 4

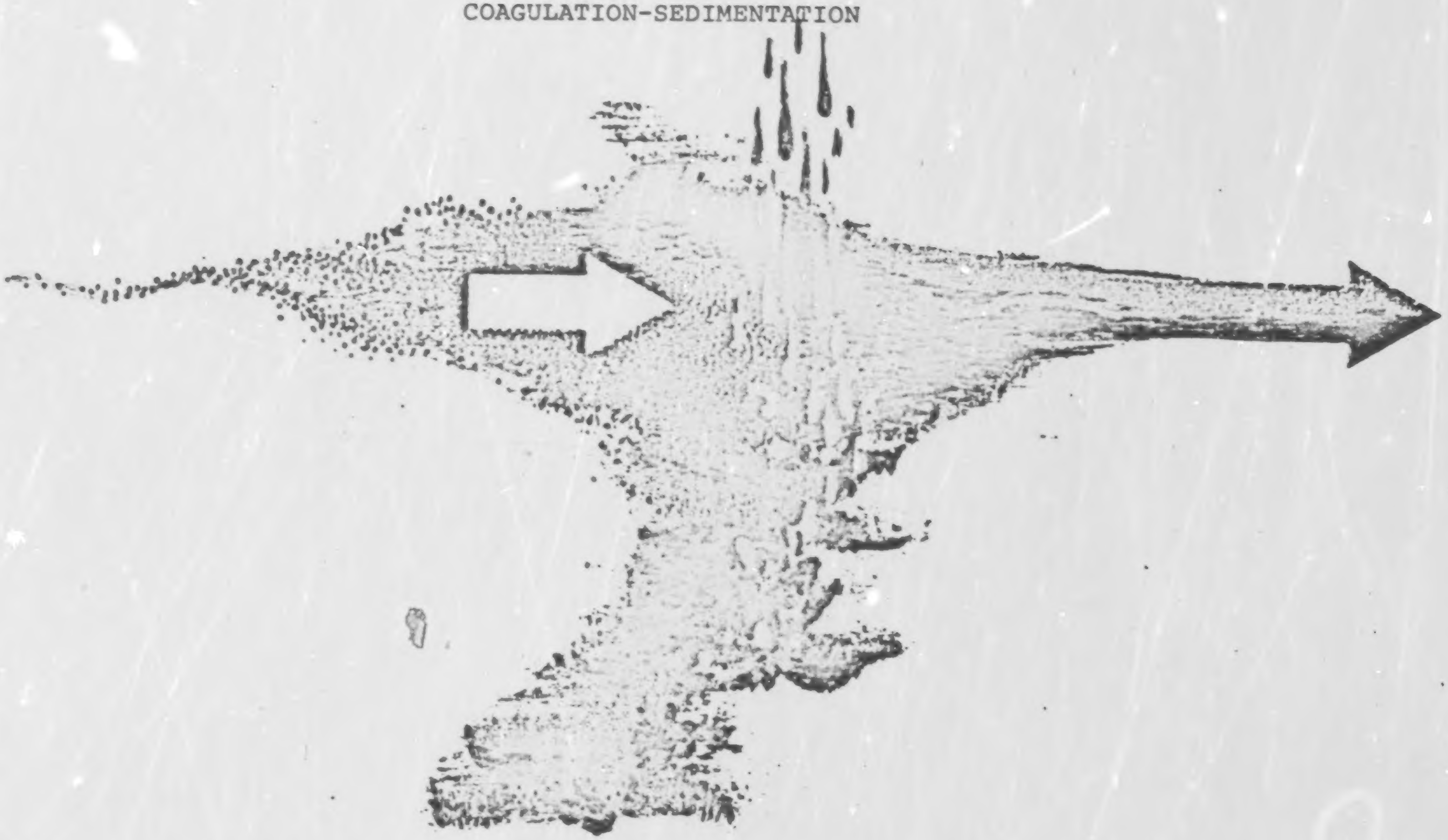
OXIDATION POND


SUNLIGHT
OXYGEN
RAW SEWAGE
OXIDATION POND
TREATED EFFLUENT

Communities occasionally make use of lagoons, stabilization ponds and oxidation ponds to retain sewage in a holding area. Oxygen, bacteria, sunlight and algae operate symbiotically to restore waste water to a quality similar to secondary treatment.

ILLUSTRATION 5

COAGULATION-SEDIMENTATION

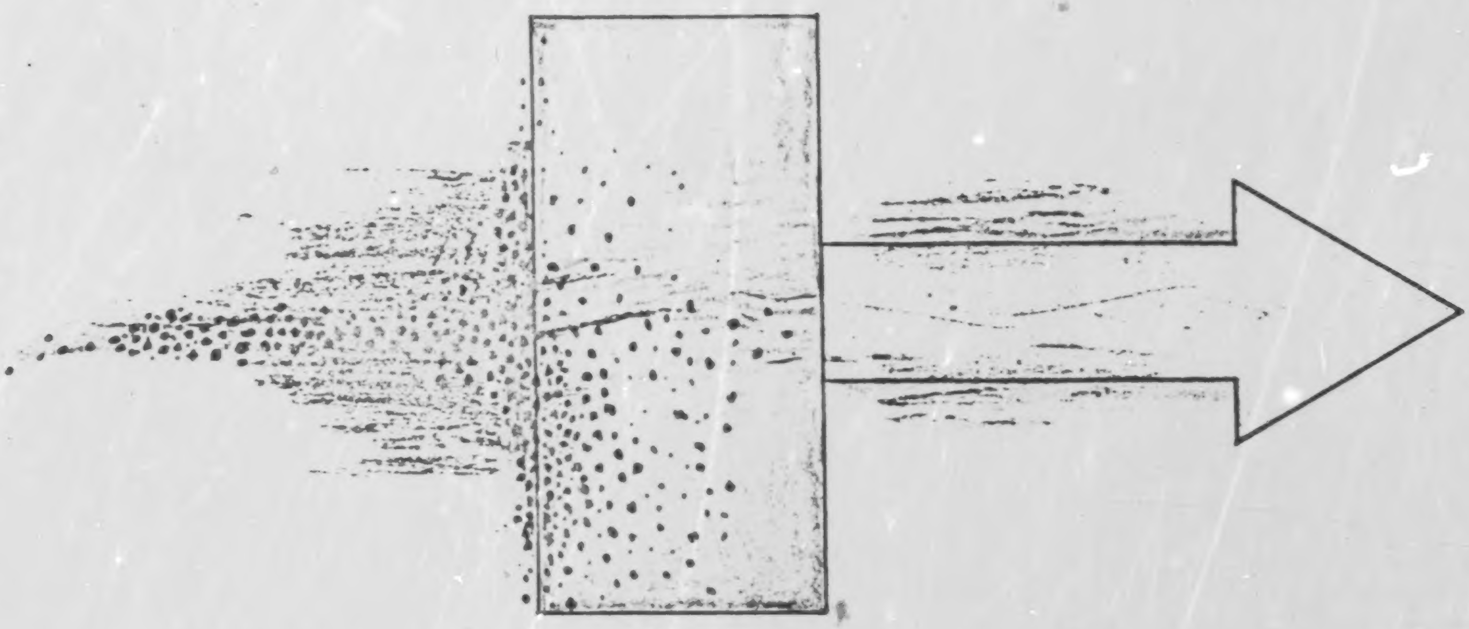


COAGULATION—SEDIMENTATION

In the coagulation-sedimentation process, alum, lime or iron salts are added to the waste water solution in order to bond with particles in the effluent, increase their weight, and speed up the settling process.

ILLUSTRATION 6

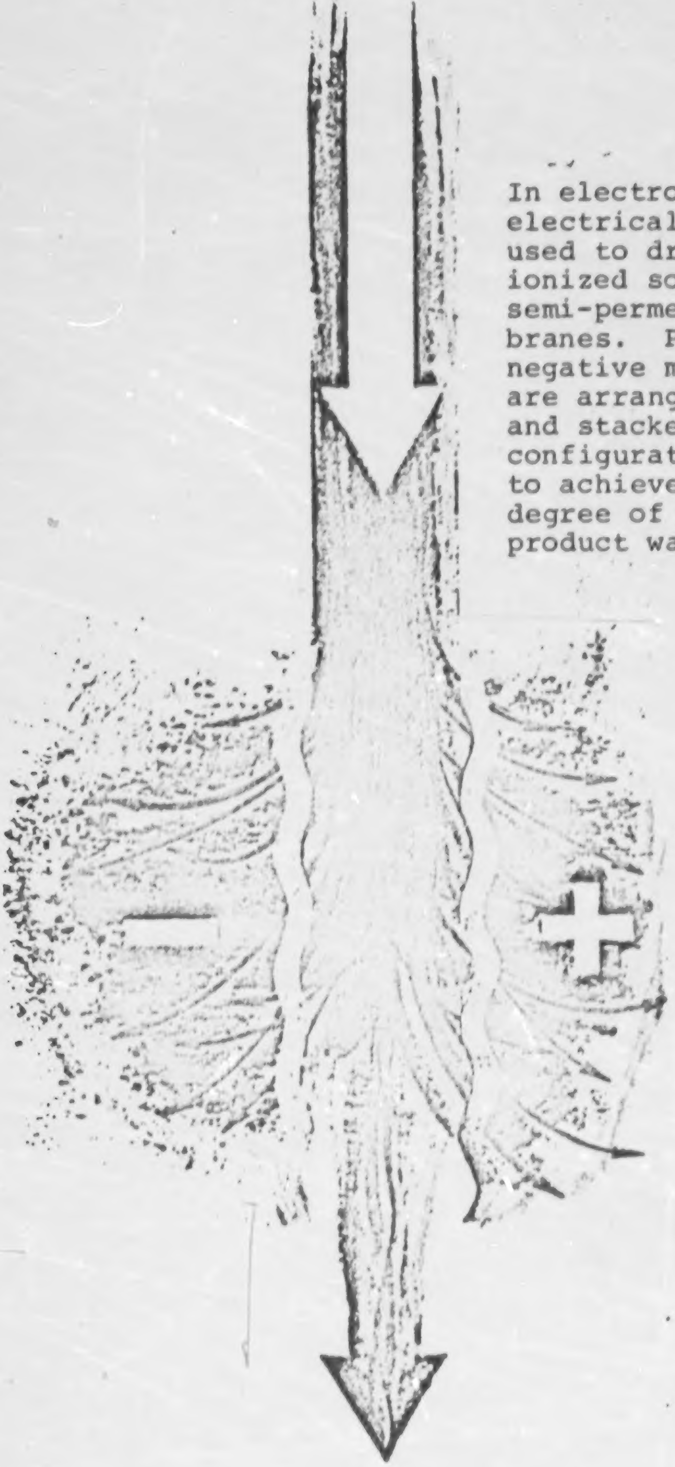
ADSORPTION



ADSORPTION

Adsorption removes refractory organics that cause foaming, taste and odor problems. In this process, waste water is filtered through activated carbon. A variety of undesirable particles adhere to the porus surface of the carbon filters.

ILLUSTRATION 7



In electrodialysis, electrical energy is used to drive dissolved ionized solids through semi-permeable membranes. Positive and negative membrane pairs are arranged in series and stacked in various configurations in order to achieve the desired degree of purity in the product waters.

ELECTRODIALYSIS

the recycling of waste water is a means of alleviating both the water pollution and the water supply problem.[7]

During the 1960's, the Federal government emphasized research and development in the water supply field. But in the last several years the emphasis has shifted to pollution control and discharge elimination. Industries are reacting to the changing Federal environment by realizing that waste discharge limitations will be more important than water supply as far as operating costs are concerned.[8] Industries are negotiating agreements with municipal sewage treatment agencies to use treated waste water for industrial purposes. The industry agrees to purchase treated waste water at less cost than potable water, and the municipal agency agrees to bring the quality of the waste water up to the standards needed by the industry. An important effect of this kind of cooperation between industries and public water treatment agencies is that such agreements conserve high quality water resources for domestic use.[9]

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[7] Office of Research and Development, U.S. Environmental Protection Agency, Evaluation of Treatment for Urban Wastewater Reuse (Washington, D.C.: U.S. Environmental Protection Agency, 1973), p. 51.

[8] Douglas B. Flett, "Waste Water Reclamation For Industrial Use," address to the Convention of the California Section, American Water Works Association, Sheraton Hotel, Honolulu, Hawaii, October 17, 1974.

[9] Douglas B. Flett, "Waste Water Reclamation For Industrial Use," American Water Works Association, California Section News (Summer, 1974), p. 19.

In addition to cooperative arrangements with municipalities, industries are increasing their "in-house" recycling of used water. In the petroleum industry, a gallon of water is recycled an average of 7.6 times; in the meat packing industry the recycling ratio is 4.0, with 3.0 in paper manufacturing and 2.6 in the auto industry. When hundreds of thousands of gallons of coolant and process waters are involved, recycling cuts operating expenses and enhances industry's ability to comply with increasingly stringent Federal and State regulations limiting the discharge of pollutants.[10]

The Oahu Sugar Company has practiced a "successive use" technique for several years. The Company draws its water from privately owned wells and from the Waiahole Ditch that transports water from the Windward side of the Island to Waipahu in Leeward Oahu. The Company uses 15 mgpd of this water in three separate industrial operations. First, the water is used in condensers at the Company's power plant. Then the same water is piped to the sugar boiling operation where it becomes process water. From there, the water is transported to the cane washing operation. Finally, the waste water is piped to the Company's fields on the Waipio Peninsula, where it is used to irrigate sugarcane.[11]

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[10] J. Eller, D. L. Ford and E. F. Gloyna, "Water Reuse and Recycling in Industry," Journal of the American Water Works Association (March, 1970), pp. 149-154.

Nationally, there have been two technological responses to the water quality situation at the municipal level. One response has been to use advanced, or tertiary, treatment processes (as described in this chapter) to improve the quality of secondary treatment effluent. The second, and most recent response, has been to replace the biological processes involved in secondary treatment with physical-chemical methods. The reason for replacing conventional secondary treatment is that biological processes are frequently upset by industrial pollutants. Many industrial wastes are toxic to the bacteria that break down raw sewage in the secondary process. But the same industrial wastes that disrupt biological processes can be removed from waste water by combinations of such physical-chemical techniques as coagulation-sedimentation, adsorption, electrodialysis and reverse osmosis. At the present time, the Environmental Protection Agency is heavily committed to developing processes and building facilities to cope with unprecedented waste water treatment challenges. Twenty-two treatment plants are planned, or under construction, that will employ processes developed under the EPA's advanced waste treatment program.[12]

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[11] Telephone conversation with John T. Humme, Oahu Sugar Company, Ltd., February 12, 1975.

One of the problems associated with waste water recycling is that as recycling becomes increasingly accepted, and as water is recycled over and over again, there will be a build up of residual constituents in the product water. Reverse osmosis is one of the few processes that can remove such residuals of secondary treatment as dissolved inorganic salts, refractory organics, and viruses from the effluent stream.[13] A recent study by Georges Belfort of the Hebrew University of Jerusalem, compared the characteristics of reverse osmosis as a leading advanced treatment process with the characteristics of such traditional primary and secondary processes as screening, filtering and biological treatment. Belfort found that advanced processes are more complicated and expensive to operate, although their rate of treatment is high and (of special interest to Oahu) their land utilization is low. Traditional processes have the advantages that they use less energy and can tolerate wider variations in feed waters:

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[12] National Environment Research Center, U.S. Environmental Protection Agency, Annual Report, Environmental Research Center, 1974, pp. 15-17.

[13] Georges Belfort, "Interfacing Newly Developed Technology Within Present Wastewater Treatment Trains," Journal of the American Water Works Association (August, 1974), pp. 504-505.

CHARACTERISTIC	PRIMARY & SECONDARY TREATMENT	ADVANCED TREATMENT
Complexity	low	high
Energy input	low	high
Training of labor	low	high
Rate of treatment	low	high
Control of process	low	high
Land area requirements	high	low
Tolerance for variation	high	low
Capital Cost	high	high
Operating Cost	low	high[14]

Although Belfort has provided a useful comparison of the characteristics of the waste water treatment processes, it should be kept in mind that advanced treatment is necessary when the product water is to be used for drinking and other uses requiring high water quality.[15]

The American Water Works Association's position on waste water re-use is that current scientific knowledge and technology are not yet sufficiently advanced to permit the direct re-use of treated waste water for municipal water supplies. The Association does approve, however, of the direct re-use of reclaimed waters for a wide variety of beneficial uses including industrial cooling, certain industrial processes, irrigation, recreational uses and ground water recharge.[16]

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[14] Ibid., p. 505.

[15] Ibid.

Ralph Stone and Company, Inc., under contract with the Office of Water Resources Research, U.S. Department of the Interior, conducted a survey of public opinion with respect to waste water re-use. One thousand randomly selected residents of ten Southern California communities participated in the study. Consumer attitudes ranged from acceptance of reclaimed waste water for non-body contact uses, to neutral to accepting attitudes toward body contact uses, and neutral to rejecting attitudes toward direct human consumption. The public's strongest objection to waste water re-use was psychological repugnance. The company surveyed water resources officials and industrial managers, and found that their attitudes toward waste water re-use are similar to the attitudes of the general public. Water supply officials tended to overestimate the public's rejection of waste water reclamation.[17]

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[16] American Water Works Association, "Use of Reclaimed Wastewaters as a Public Water Supply Source," statement adopted by the Board of Directors, June 18, 1971.

[17] Ralph Stone and Company, Inc., Wastewater Reclamation: Socio-Economics, Technology and Public Acceptance (Los Angeles, California: Ralph Stone and Company, Inc., 1974). The section on public acceptance of reclaimed water is relevant in this context.

The Board of Water Supply's position on waste water re-use is that although the technology exists to render reclaimed waste water fit for human consumption, it is advisable to use such water for cooling, irrigation, recreation and ground water recharge because of the major psychological barriers involved in the domestic use of reclaimed waste water.[18]

Reclaiming waste water for either direct or indirect domestic use requires extensive and costly treatment. Mainland water supply agencies are experiencing rapidly rising water treatment costs. As American Water Works Association President, Robert B. Hilbert said recently, "The era of cheap water is over. Saving the environment is expensive; saving water and making it all we want it to be won't be cheap either."[19]

The Honolulu Board of Water Supply has not been greatly affected by rising water treatment costs. Oahu's natural ground water supplies remain pure. Water treatment in the form of chlorination is routinely applied to only the small percentage (less than 5%) of Honolulu's water that is derived from surface water sources in Nuuanu Valley. The Board of Water Supply constantly monitors the quality of

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[18] George Yuen, "Water for the Future--Is Desalting the Answer?" March 9, 1973.

[19] American Water Works Association, "President Hilbert Responds to Unsafe Drinking Water Reports," Willing Water (December, 1974), p. 1.

Oahu's domestic water. The Board's Microbiological Laboratory examined over 11,000 water samples, and the Chemical Laboratory examined over 7,000 samples, in 1973. The bacterial quality of Oahu's water continues to be excellent, and well within the U.S. Public Health Service guidelines established for municipal water. In addition to the routine measurement of the saline content in key wells, the Chemical Laboratory monitors pesticides and mercury in the water supply. To date, no pesticide or mercury contamination has been found in Oahu's water supply.[20]

In November, 1974, water treatment became a matter of national concern when the Environmental Defense Fund (EDF), a public interest group of scientists and lawyers, reported the results of studies that show a possible link between cancer and the consumption of Mississippi River water by people living in Louisiana. The day after the EDF announcement, the U.S. Environmental Protection Agency confirmed the presence of 66 organic compounds, some of which are known to produce cancer in laboratory animals, in the New Orleans municipal water supply.[21]

The problem involves chlorination, the same disinfectant treatment used by most water supply agencies in the United States. When water from a polluted source, such as the Mississippi River, is brought into a treatment plant, chlorine interacts with industrial and agricultural wastes to produce chemical compounds that have been proven to be carcinogenic in laboratory experiments. The Environmental Protection Agency has responded by ordering a nationwide study of domestic water supplies. The first phase of the study will determine the concentration, and possible effects, of various chemicals in U.S. drinking water systems. Preliminary results should be ready by mid-1975. The second phase of the EPA study will attempt to locate sources of contamination and evaluate techniques for either preventing contamination, or removing it from municipal water supplies. It is already known that treatment with activated charcoal will remove some of the potentially dangerous organic compounds.[22]

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[20] Honolulu Board of Water Supply, 1973 Annual Report, p. 9.

[21] "Drinking Water: Another Source of Carcinogens?" Science, November 29, 1974, pp. 809-810.

President Robert B. Hilbert of the American Water Works Association responded to the EDF and EPA reports by cautioning against overreaction. He pointed out that human beings have tolerances which permit the ingestion, over a lifetime, of substances that are potentially harmful under laboratory conditions. President Hilbert spoke of the folly of spending huge sums of money to remove what may prove to be harmless substances from municipal water supplies. And he urged accelerated research to determine whether compounds present in water supplies are really harmful to human beings.[23]

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[22] Ibid.

If chlorine treatment is found to be harmful to public health, there are two other practical alternatives: ozone treatment, and treatment by ultraviolet light. Both of these alternatives are more expensive than chlorination.[24]

The EDF and EPA disclosures had the additional effect of accelerating the passage of the Safe Drinking Water Act. The Act, which has been signed into law by President Ford, enables the EPA to set limits for chemical contaminants in community water supplies, and establish standards for techniques designed to remove chemical contamination.[25] At present, there are no standards regulating chemical contaminants in municipal water supplies. The U.S. Public Health Service has established bacterial limits, but no limits on the kind of substances revealed by the EPA.

The fluoridation of community water supplies may be considered in the context of water treatment because fluoridation is an accepted treatment practice in several thousand communities in the United States and in many foreign countries, including the Soviet Union. Although fluoridation is a routine matter for water supply professionals, it is not a routine matter for many people in the United States who oppose it for a variety of reasons. The writer gathered evidence and read the arguments on both sides of the fluoridation question, and became convinced that it is a desirable treatment practice for the people of Oahu.

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[23] "President Hilbert Responds to Unsafe Drinking Water Reports," Willing Water, p. 1.

[24] Robert B. Dean, "Toxicity of Wastewater Disinfectants," News of Environmental Research in Cincinnati (July 5, 1974), pp. 1-4.

[25] "Drinking Water: Another Source of Carcinogens?"; "Washington Report," Willing Water (December, 1974), p. 10.

Fluoridation became an impassioned issue on the Island of Hawaii in the November, 1974, election campaign. In that election, the Big Island's voters rejected an ordinance providing for the fluoridation of the public water supply. The voting was lopsided:

For Fluoridation:	5,401
Against Fluoridation:	21,724[26]

The results of the referendum on Hawaii indicate that the political climate on Oahu may be unfavorable to the introduction of fluoridation by the Honolulu Board of Water Supply. Nevertheless, the Board of Water Supply should consider fluoridation because the evidence favoring it is substantial.

Fluoridation began in several American cities in 1945. Thirty years later, the number of communities with fluoridated drinking water has grown to over 5,000; and about 100 million people in the United States are drinking fluoridated water every day.[27] A recent survey of the water supply agencies serving 45 medium and large U.S. cities indicated the following:

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[26] Honolulu Advertiser, November 6, 1974, p. A5.

Cities providing fluoridation:	28
Natural fluorides present in water:	1
Cities, including Honolulu, not providing fluoridation:	16[28]

Locally, the Army began fluoridating the water supply systems at Schofield Barracks and Fort Shafter in 1955, and the Navy has been fluoridating the Pearl Harbor supply since 1958.[29]

The fluoridation of drinking water has been found to be an effective method of preventing tooth decay, especially among young children. Fluoridation reduces the incidence of tooth decay up to 50 percent. It has been accepted and endorsed by virtually every scientific and health organization in the United States.[30]

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[27] Ervin Bellack, Fluoridation Engineering Manual (Washington, D.C.: U.S. Environmental Protection Agency, 1972), pp. 2, 3; Honolulu Advertiser, November 2, 1974, p. A4.

[28] Office of Council Services, City and County of Honolulu, "A Comparative Study of Forty-five Major U.S. Water Supply Agencies," Honolulu, 1974. (Mimeographed.)

[29] Honolulu Board of Water Supply, Fluoridation Report (Honolulu: Honolulu Board of Water Supply, November, 1972), p. 5.

[30] U.S. Department of Health, Education and Welfare, Fluoridation: No Better Health Investment (Washington, D.C.: U.S. Government Printing Office, 1970). The entire pamphlet is relevant in this context.

The following statement by Dr. Charles C. Edwards, Assistant Secretary for Health, U.S. Department of Health, Education and Welfare, summarizes the effectiveness of fluoridation:

> Fluoridation is a proven health measure which can alleviate one of the Nation's leading health problems--dental decay. Decades of research, followed by over a quarter-century of practical demonstration, have shown that the adjustment of the fluoride content of a water supply is a safe and effective means of preventing nearly two out of three cavities.
>
> No other preventive dental health measure can as effectively reach all Americans without regard to socio-economic or educational status. Studies have shown that costs of dental care for children are about one-half as much in fluoridated communities as in non-fluoridated communities.
>
> The prevalence and expense of dental decay underscore the pressing need to make the benefits of fluoridation available to everyone.[31]

The fluoridation of drinking water not only benefits children, it benefits adults throughout their lives. The U.S. Public Health Service has recently released three reports concerning an investigation of the dental health of adults living in a naturally fluoridated area of Great Britain. The reports show that the residents have significantly less tooth decay, fewer missing teeth, and less need for partial dentures than persons the same age living in nonfluoridated areas.[32] Not only does fluoridation reduce tooth decay dramatically, the drinking of fluoridated water throughout life helps to prevent osteoporosis (a deterioration of bone structure common among older people). Studies by the American Medical Association show that people drinking fluoridated water all of their lives have a significantly lower incidence of arteriosclerosis (hardening of the arteries).[33]

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[31] Charles E. Edwards, U.S. Department of Health, Education and Welfare Statement on Fluoridation (Washington, D.C.: U.S. Department of Health, Education and Welfare, July 9, 1973), pp. 1, 2.

[32] Public Health Service, U.S. Department of Health, Education and Welfare, Adult Dental Health Benefits From

The National Academy of Sciences has recognized fluoride as an essential Mineral Nutrient:

> Fluoride is present in small but widely varying concentrations in practically all soils, water supplies, plants, and animals. It is therefore a constituent of all normal diets. Fluoride is incorporated in the structure of the teeth and is required for maximal resistance to dental caries.
>
> It is evident that the daily fluoride intake in many areas of the United States is not sufficient to afford optimal protection against dental caries. Standardization of water supplies by addition of fluoride to bring the concentration to 1 mg per liter has proven to be a safe, economical, and efficient way to reduce the incidence of tooth decay--a very important nutritional public health measure in areas where natural water supplies contain less than this amount.[34]

Research in areas of the United States where people have lived all of their lives on water containing 8 parts per million fluoride shows no ill effects to health from the

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Fluoridation Documented in New American and British Reports (Bethesda, Maryland: U.S. Department of Health, Education and Welfare, 1972), pp. 1-4.

[33] Fluoridation Report, p. 13.

[34] National Academy of Sciences, Recommended Dietary Allowances (Washington, D.C.: National Academy of Sciences, 1974), pp. 98, 99.

presence of fluoride. A concentration of 8 parts per million fluoride is about ten times higher than the concentration recommended for Hawaii. Nevertheless, the people living in these high concentration areas have grown up and lived in good health.[35] The following statement by the Council of the Society of Toxicology summarizes scientific opinion on the safety of fluoridation:

> From a critical review of the voluminous and steadily growing literature on the biological effects of inorganic fluoride, no evidence has been found of an ill effect of water fluoridation in 1 ppm in temperate climates. In the United States, there are over 10 million people drinking naturally fluoridated water at near optimal concentrations or higher. These waters have been consumed by large numbers of people for many years. Therefore, an extraordinary and exceptional reliability is conferred on the safety of water fluoridation because nature in a sense has already made the demonstration in hundreds of communities where the drinking water naturally contains fluoride. Under public health authorities, the Society of Toxicology finds water fluoridation to be a safe measure.[36]

In view of the benefits of fluoridation, and its safety, the fluoridation of water supplies is a public health care bargain. The results of a study published by the U.S. Public Health Service in 1968 indicated that the average cost of fluoridation is $0.13 per person, per year.[37] The Honolulu Board of Water Supply's 1972 Fluoridation Report estimated the costs of fluoridation as follows:

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[35] U.S. Department of Health, Education and Welfare, Fluoridation: Nature's Way to Prevent Tooth Decay (Washington, D.C.: U.S. Government Printing Office, 1972). The entire pamphlet is relevant.

[36] Council of the Society of Toxicology, Water Fluoridation Safety Statement, October 30, 1968, p. 1.

Initial expense:	$388,000.00
Annual Operating expense:	237,000.00
Annual cost per capita:	0.43
Cost per 1,000 gallons:	0.0063[38]

The annual per capita cost would be higher on Oahu than on the mainland primarily because of the number and the Island-wide dispersion of Oahu's water sources. Forty-nine separate fluoridation installations would be necessary to provide service throughout Oahu.[39]

The equipment and procedures for fluoridating community water supplies present no major difficulties. Water treatment plant operators fluoridate water supplies as a matter of routine, and the procedures for monitoring the fluoride content of the water are well understood.[40]

If fluoridation is beneficial, safe, inexpensive and presents no special technical problems, why was fluoridation rejected on the Big Island, and why is it rejected in about

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[37] U.S. Public Health Service, Better Teeth for Life: Fluoridation (Washington, D.C.: U.S. Government Printing Office, 1968). The entire pamphlet is relevant.

[38] Fluoridation Report, p. 23.

[39] Ibid.

[40] Ervin Bellack, "Methods and Materials for Fluoride Analysis," Journal of the American Water Works Association, Vol. 64 (January, 1974), pp. 62-66.

60 percent of community referendums on the question? The answer is that anti-fluoridationists have effectively created doubts and fears among the voting public. The following charges have been made against fluoridation:

1. Fluoridation is part of an international communist plot to weaken the people of the United States. (The fact is that the Soviet Union practices extensive fluoridation of its own water supplies.)

2. Fluoridation presents a danger to health. (All of the evidence indicates that the opposite is true.)

3. Fluorides are poisonous. (Many substances in common use are beneficial in small quantities, but harmful when used in large concentrations. For example, sodium chloride is poisonous in large amounts, but it benefits the human body when used in small quantities as table salt.)

4. Fluoridation violates the freedom of individual choice. (The following statement by legal scholar, William H. Butler, reprinted in a publication of the American Dental Association, is offered to refute the contention that fluoridation is an infringement of individual rights:

> Accordingly, it may be safely concluded today that every argument which the ingenuity of the opponents of fluoridation has found has been heard and answered by the courts. It is now a settled principle of law that a community has the inherent right to fluoridate the public water supplies. In so doing, it is not practicing medicine, engaging in socialized medicine, giving mass medication or violating the pharmaceutical laws. The individual's rights, which are protected under the Constitution, do not extend to prevent public programs of this kind. In view of this unanimity and comprehensiveness of judicial opinion, it is unlikely that there

will be any decisions in the future adverse to fluoridation of public water supplies.)[41]

All four of the above charges against fluoridation surfaced during the weeks preceding the referendum on the Island of Hawaii. Anti-fluoridationists formed an unusual coalition: strongly liberal natural foods advocates joined staunchly conservative defenders of the freedom of individual choice in their opposition to fluoridation. William H. Butler's remarks about the unanimity of judicial opinion notwithstanding, former jurist, Nelson K. Doi, now Lieutenant Governor of Hawaii, opposed fluoridation on legal grounds. Of twenty general election candidates expressing an opinion on the issue, only three advocated the fluoridation of the water supply. Moreover, anti-fluoridationists took advantage of the recent drought in Hawaii by maintaining that money to fluoridate water would be better spent on developing more water resources.[42]

Supporters of the fluoridation proposal included practically all of the Island's doctors and dentists, the politically potent International Longshoreman's and Warehouseman's Union (ILWU), Local 142, the popular former Mayor of Hawaii, Shunichi Kimura, and County Councilman Ikuo Hisaoka, who won reelection despite the fact that the fluoridation proposal was resoundingly defeated.[43]

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[41] American Dental Association, Answers to Criticisms of Fluoridation (Chicago, Illinois: American Dental Association), pp. 3-12.

[42] Honolulu Advertiser, November 2, 1974, p. A4.

The basic factor in the defeat of fluoridation on Hawaii in 1974 was that anti-fluoridationists were more effective in communicating their side of the issue to the electorate. Unfortunately, many voters were unable, or unwilling, to make a valid judgment based on the scientific facts on fluoridation. In order to gain public support for fluoridation, water supply officials should take a leading role in providing the public with factual information on the benefits and safety of fluoridation. Water supply managers should convince the public that they have the expertise to administer an effective fluoridation program.[44]

The legislative history of fluoridation in the State of Hawaii amounts to a series of false starts. In 1955, the Territorial Legislature passed a bill authorizing communities to fluoridate their water supplies. But Governor Samuel King pocket-vetoed the measure on the grounds that the public needed more time to become informed about the issue. Fluoridation Bills were brought before the State

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[43] Ibid.

[44] Answers to Criticisms of Fluoridation, p. 12; Virginia H. Knauer, Address of the Special Assistant to the President For Consumer Affairs to the American Water Works Association, Boston, Massachusetts, June 18, 1974.

Legislature in 1967, 1968 and 1969, but were not acted upon.[45]

The Citizens Committee for Fluoridation was formed in 1963 and requested the City Council to consider the fluoridation question. After lengthy discussion, the Council voted 6-3 to defer the question for an indefinite period. Three years later, the Council passed a fluoridation measure by a 5-4 vote, but Mayor Blaisdell vetoed the measure, and the Council was not able to override his veto.[46]

At the present time, the Honolulu Board of Water Supply is bound by two legal opinions issued by the Corporation Counsel in 1963. These opinions state that the City Council has the authority to require the fluoridation of Oahu's water supply, and that the Board of Water Supply may not authorize fluoridation without the approval of the City Council.[47]

The Board has maintained a neutral position during the two decades of controversy over fluoridation. The Board's present position was stated in a leaflet distributed to the public in 1955:

> The attitude of the Board of Water Supply continues to be substantially as follows: We are seriously considering fluoridation and shall favor the addition of fluoride to the Honolulu water supply when and if (a) it is reasonably certain that the

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[45] Fluoridation Report, p. 6.

[46] Ibid.

[47] Ibid., p. 8.

> desired results will be accomplished without any harmful effects, (b) it is the wish of a majority of our consumers that the fluoride content of their water supply be so adjusted, even recognizing that, eventually in one way or another, they will have to pay for it, and (c) the Board is satisfied that it has the legal right to add fluoride to the water which it furnishes to its consumers.[48]

Twenty years have elapsed since the Board established the above position. It is the opinion of the writer that this position should be updated and include a clear statement in favor of the fluoridation of Oahu's water supply. As to point (a) above, the scientific evidence is clear that fluoridation is safe and effective. As to point (b), the writer believes that the Board should take the initiative in informing the public of the benefits, safety and feasibility of fluoridating Oahu's water supply. As to point (c), the Board has the right to fluoridate Oahu's water supply provided that fluoridation is authorized by the City Council.

For more than two decades the fluoridation controversy has boiled and cooled, but there have been no positive results. In view of the public benefit to be gained from fluoridation, the Board should consider abandoning its long-held neutral position and become an advocate of the fluoridation of Oahu's water supply.

Fluoridation should be kept in perspective. It is simply one of many effective and widely accepted water treatment practices. Part of the problem involved in gaining acceptance for fluoridation on Oahu lies in the fact that our natural ground water supplies are exceptionally pure and, as a general rule, require no treatment at all. If waste water recycling with all of the accompanying water treatment processes becomes a reality on Oahu, one would expect the climate of opinion toward fluoridation to become more favorable.

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[48] Fluoridation Report, p. 9; Sixteenth Biennial Report, p. 33.

In a recent address to the Conference of Hawaiian Sugar Technologists, Manager and Chief Engineer, Edward Hirata, stated that the first supplementary water resource (beyond our natural ground water supplies) will probably be the recycling of treated waste water for irrigation. The following figures indicate average daily consumption by water users on Oahu:

	(millions of gallons per day)
Agriculture:	226
Board of Water Supply:	122
Military:	34
Private Systems including Industry:	19
Total consumption:	401[49]

Oahu's agricultural interests use over one half of the water that is drawn from the natural underground supplies. If major agricultural water users would accep treated waste water for irrigation, there would be a considerable beneficial effect on the natural ground water supplies. Oahu's Sugar Plantations have been reluctant to commit themselves to accepting treated sewage effluent on a major scale. The plantations acknowledge that they have been using treated effluent from the Wahiawa Sewage Treatment Plant since 1928, and the Makakilo and Nanakai Sewage Treatment Plants near Barbers Point also discharge their effluent into sugar irrigation systems. But the quantities of effluent from these three plants are very small when compared to the use of natural ground water for irrigation.[50]

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[49] Edward Hirata, "Technical and Environmental Aspects of Using Municipal Sewage for Sugarcane Irrigation," address to the Conference of Hawaiian Sugar Technologists, Honolulu, Hawaii, Ilikai Hotel, November 13, 1974.

If the Board of Water Supply is to achieve the trade-off of quantities of treated effluent for high quality potable water, it will have to convince Oahu's agricultural interests that such an exchange is valuable to the community and is economically and technically feasible. As indicated in Chapter 6, the Board took a leading role in opening a dialogue with the plantations by calling a meeting of the Oahu Water Users Association in April, 1974. The Board is attempting to maintain communications with major water users on a continuous basis. An active Oahu Water Users Association could constitute a forum for discussion leading to agreement on the allocation of water resources and on waste water reuse for irrigation.[51]

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[50] "Technical and Environmental Aspects of Using Municipal Sewage for Sugarcane Irrigation"; interview with Richard W. K. Lum, Honolulu Board of Water Supply, Planning, Resources and Research Division, January 20, 1974.

There are four classes of technical questions to be answered before treated waste water can be recycled for agricultural use:

1. How would recycling affect the quality of the underlying ground water?
2. How would it affect sugar yield?
3. How would it affect the existing irrigation system?
4. How would it affect future irrigation practices?[52]

No water recycling techniques should be implemented until it can be demonstrated that recycling will not adversely affect the quality of the underground water supply. Effluent from secondary sewage treatment plants contains pathogenic viruses and dissolved solids such as nitrogen and phosphorus. The question is whether the soil can filter out viruses and dissolved solids before irrigation waters infiltrate the basal water supply. In September, 1971, the University of Hawaii's Office of Water Resources Research began a study that has provided considerable factual material for answering this first question. The purpose of the study is described as follows:

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[51] Interview with Edward Hirata, Honolulu Board of Water Supply, November 4, 1974.

[52] "Technical and Environmental Aspects of Using Municipal Sewage for Sugarcane Irrigation."

> An investigation of recycling sewage effluent by irrigation under Hawaiian conditions is being conducted in pilot field studies near Mililani Town in central Oahu under the sponsorship of the Board of Water Supply and the Division of Sewers, City and County of Honolulu. The primary objective of the project is to determine the feasibility of waste water application to the soil and its probable effects on the quality of ground water in terms of dissolved materials and viruses. Corollary objectives are to ascertain its effects on sugar cane yield and grass lands.[53]

The study involves the irrigation of sugar cane with secondary effluent from the Mililani Sewage Treatment Plant. The Mililani site was chosen because of the proximity of the Plant, and because the adjacent sugar cane fields are grown on oxisol soil, the same type of soil that supports the growth of 90% of the sugar cane under irrigation on Oahu.[54] The study measures the physical, chemical, bacterial and viral results of applying treated effluent to sugar cane and grasslands from November, 1971, to the present. Preliminary results confirm that pathogenic viruses can survive secondary sewage treatment even after chlorination. But (and this is the crucial finding) the soils being tested are highly effective in removing viruses from the applied effluent.[55] Measurements of the soils' capacity to filter dissolved solids are not entirely complete, but indications are that there will be no detrimental effects on the underground water supply from the judicious application of secondary effluent for irrigation.

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[53] L. Stephen Lau, et al., Water Recycling of Sewage Effluent by Irrigation: A Field Study on Oahu (Honolulu: Water Resources Research Center, November, 1972), p. v.

[54] Gordon L. Dugan, et al., "Land Disposal of Sewage in Hawaii--A Reality?", paper presented to the Conference of the Water Pollution Control Federation, Denver, Colorado, October 6-11, 1974. The entire paper is relevant to a consideration of the Mililani study.

[55] Ibid., p. 38.

As for the effect of treated effluent on sugar yield, few definite findings are available yet. Although no actual weighing program has been conducted, the researchers estimate that the sugar cane receiving treated effluent had substantially greater growth than control cane irrigated by potable water. This phenomenon may be due to the nutrient properties of sewage effluent. Testing showed that the quality of the effluent-grown cane was equivalent to that of the control cane.[56] If these preliminary findings are confirmed by additional research, the results of the Mililani study could influence sugar planters to accept secondary effluent irrigation for their crops.

As to the question of how recycling would affect the existing irrigation system, it is clear that new transmission mains and storage facilities will have to be built, and they will have to be connected to present irrigation facilities. Most sewage treatment plants, including the important facility to be built at Honouliuli in the Ewa district, are located at low elevations. Fortunately, the Honouliuli plant and all treatment plants built in compliance with the Federal Water Pollution Control Act of 1972, will be designed with a recycling capability. Nevertheless, it will be necessary to pump treated effluent to higher elevations. A transmission system will have to be designed and built, and energy costs will have to be anticipated. Adequate research has not been done on the technological applications and costs involved in supplying effluent for irrigation. This area should be a major concern for the Board of Water Supply's Planning, Resources and Research Division. Present estimates are that a maximum of 30 mgpd of treated effluent could be available for exchange with Oahu's agricultural interests.[57] In view of the increasing demand on Oahu's water resources, and considering that agriculture uses 226 mgpd, one might anticipate greater application of recycled water for irrigation.

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[56] Ibid., p. 24.

A fourth technical question involves the effect of recycling on future irrigation practices. The sugar industry is rapidly converting from furrow irrigation to drip irrigation. Drip irrigation is a system which feeds water to the roots of the sugar cane through a network of small diameter polyethylene tubes with tiny orifices. The tubes are installed between rows of cane, and lie on or near the surface of the soil. In subsurface irrigation, the tubes are installed about 40 cm below the surface.[58] Drip irrigation is expected to be a considerable improvement over furrow irrigation, and somewhat better than sprinkler irrigation. Capital costs involved in drip irrigation will be relatively low, operating costs will be lower than with other methods, water will be used more efficiently and sugar production is expected to be higher with drip irrigation.[59]

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[57] "Technical and Environmental Aspects of Using Municipal Sewage for Sugarcane Irrigation."

[58] Warren Gibson, Hydraulics, Mechanics and Economics of Subsurface and Drip Irrigation of Hawaiian Sugarcane

The first successful application of drip irrigation technology took place at the Kunia agricultural substation in 1970. In 1973, drip irrigation was installed on approximately 1,200 hectares of sugar cane (a hectare is the metric equivalent of 2.471 acres), and the Hawaiian Sugar Planters' Association expects that most of the 48,000 hectares of sugar cane under irrigation will eventually be irrigated by the drip process.[60]

Warren Gibson, Head of the Engineering Department, Hawaiian Sugar Planters' Association, has stated that the greatest single problem associated with drip irrigation is the plugging of the tiny port holes in the tubing. If secondary treated sewage effluent is to be used in conjunction with drip irrigation systems, it seems certain that the effluent will have to undergo additional treatment to remove

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(Hawaiian Sugar Planters' Association: Honolulu, Hawaii). The entire pamphlet is relevant in this context.

[59] Warren Gibson, letter to the Chairman of the Board of Water Supply, October 7, 1974; "Hydraulics, Mechanics and Economics of Subsurface and Drip Irrigation of Hawaiian Sugarcane."

[60] Ibid.

particles which could block the tiny port holes. The Hawaiian Sugar Planters' Association has launched an extensive research program aimed at coping with the problem of moving irrigation water through the drip irrigation system to the sugar cane.[61]

In the opinion of the writer, the technical problems involved in recycling waste water for irrigation will be solved. Agreement will be reached among the public agencies and private water users concerned with the allocation of Oahu's water resources. The recycling of waste water for agricultural purposes will provide a major supplement to the Island's natural ground water supply. In the more distant future, demands on water resources may require Oahu's people to accept the recycling of waste water for domestic purposes.

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[61] "Technical and Environmental Aspects of Using Municipal Sewage for Sugarcane Irrigation"; "Hydraulics, Mechanics and Economics of Subsurface and Drip Irrigation of Hawaiian Sugarcane."

Chapter 9

WATER RESOURCE CONSERVATION

The conservation of finite water resources is a vital concern for an Island society experiencing increasing growth. There are opportunities for water resource conservation as rains fall on the land and become surface waters and ground waters, as water passes through man-made supply systems, and as it is used for agricultural, industrial and domestic purposes.

Watersheds are land areas that contribute water through infiltration to the underground water supply. Water resource conservation begins with watershed management. The objectives of watershed management are to increase the yields of usable water, and decrease runoff, erosion, siltation and flooding. The challenge of watershed management is to detain the water from rainfall so that greater quantities percolate through the soil and become available for later use as ground water or streamflow.[1]

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[1] Robert E. Nelson, "Water for Hawaii--Mountain Watersheds," address to the Water for Hawaii Conference, Honolulu, Hawaii, January 31, February 1, 1974; Chester Lao, Tantalus-Roundtop Hydrologic Problem (Honolulu, Hawaii: Honolulu Board of Water Supply, 1971). The entire report is relevant in this context.

Reforestation is a major watershed management practice. For many years the Forestry Division of the Department of Land and Natural Resources, and its predecessor, the Territorial Department of Agriculture and Forestry, have been carrying out a reforestation program involving the planting of millions of trees throughout the Islands. When trees are planted in heavy rainfall areas, they help to increase the amount of water that infiltrates the earth. Research has established that non-forested areas experience greater runoff than adjacent forested areas. But watershed managers must be cautious in their choice of trees and ground cover. Some trees and plants exhale considerable amounts of water through transpiration. Under some rainfall and soil conditions, the planting of certain vegetation can actually result in a net loss of water resources available for human use.[2]

The U.S. Geological Survey has recognized the protection of Oahu's ground water resources from contamination as a major water conservation concern. The State Department of Land and Natural Resources has established watershed areas for the protection and development of springs, streams and other water supply sources. The protection of Oahu's watersheds from contamination has been a concern of the Honolulu Board of Water Supply for many years. The Board works with

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[2] Water Resources in Hawaii, pp. 50-56; "Water for Hawaii-Mountain Watersheds."

Wardens of the Forestry Division, Department of Land and Natural Resources, to restrict the entry of unauthorized persons to watershed areas. Watershed trespassers are subject to a $500 fine and up to six months imprisonment.[3]

The State Land Use Commission is responsible for making major land use decisions throughout the Islands. There are four land use designations: urban, rural, agriculture and conservation. The conservation designation is most desirable from the water resources standpoint because conservation lands (especially forested areas) provide the best conditions for the infiltration of rain water and the replenishment of the underground water supply. Moreover, lands classified in one of the three other land use categories place higher demands on the Island's water resources. Richard W. K. Lum, head of the Board's Planning Resources and Research Division, has maintained a long-standing interest in land use on Oahu. During 1973 and 1974, Mr. Lum led the Board's effort to convince the State Land Use Commission to change the designation of 25,673 acres of land in Laie, Kahuku, Waimea, Wahiawa and Waipio from agriculture to conservation. Mr. Lum made the case that additional conservation lands will be needed to offset urbanization and increasing demands on Oahu's water resources. But when the Land Use Commission made public the results of its five year boundary review in December, 1974, the Board's request was disapproved.[4]

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[3] Kiyoshi J. Takasaki, Hydrologic Conditions Related to Subsurface and Surface Disposal of Wastes in Hawaii (Washington, D.C.: U.S. Geological Survey, 1974), pp. 1-4; Honolulu Board of Water Supply, Safeguarding Our Water Supply (Honolulu, Hawaii: Honolulu Board of Water Supply). Pamphlet.

The writer corresponded with the Headquarters of the U.S. Army Engineer Division stationed at Fort Shafter, and with the Soil Conservation Service (SCS), U.S. Department of Agriculture, to learn the extent of water resource conservation activities by these agencies. The Army Engineers are primarily concerned with the construction of levees, debris basins, channel improvements and other flood control measures on certain streams in Oahu. The Soil Conservation Service is more directly involved with water resource conservation. The SCS works with farm operators to improve their irrigation systems including drip and sprinkler irrigation. The SCS provides technical advice and financial assistance for the construction of small dams, ponds, pipelines, and linings for ditches and ponds. The Soil Conservation Service is also involved in flood and erosion control through its watershed conservation programs. The agency has completed three watershed conservation programs on Oahu. The land treatment program associated with these watersheds uses techniques designed to retain runoff and increase infiltration in the upper watershed areas. These measures include proper cropping systems, contour farming, pasture management and reforestation.[5]

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[4] Interview with Richard W. K. Lum, Honolulu Board of Water Supply, January 20, 1974; Honolulu Advertiser, December 21, 1974, p. A4; Kazu Hayashida, "Flood and Erosion Problems," address to the Water for Hawaii Conference, January 31, 1974.

Water resource conservation measures may be divided into two categories: measures intended to conserve surface water, and measures intended to conserve ground water. Surface water conservation techniques involve the construction of dams, reservoirs, catchments and impoundments. The damming of surface streams has been considered impractical on Oahu for a number of reasons. Oahu's streams are flashy in nature; they are practically torrential after a heavy rainfall. Many of the streambeds flow through steep mountainous areas, and the surrounding soil and substrata are generally so porous that waters can not be effectively retained behind a dam. However, the damming of streams to produce reservoirs may be feasible in certain situations. The Division of Water and Land Development, for example, is strongly supporting the construction of a dam, reservoir and supporting facilities on Kohakohau Stream as part of the South Kohala Water Project on the Island of Hawaii.[6]

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[5] Wesley F. Peel, Notice of Report on Survey For Flood Control and Allied Purposes, Wailupe Stream, Oahu, Hawaii (U.S. Army Engineer Division, Fort Shafter, Hawaii, October 7, 1974); Saku Nakamura, Letter from the Acting District Conservationist, Soil Conservation Service, to the Chairman of the Board of Water Supply, November 4, 1974; Soil Conservation Service, U.S. Department of Agriculture, Small Watershed Projects in Hawaii (Portland, Oregon: Soil Conservation Service, 1971); Water Resources in Hawaii, p. 52.

The Kohakohau Dam is a major water resource development project. On a smaller scale, diversion dams may be constructed across streams in order to channel stream flows into tunnels designed to recharge the subterranean ground water supply. As indicated in Chapter 2, the Honolulu Board of Water Supply showed considerable interest in damming Palolo, Manoa and Nuuanu Streams and diverting a portion of the stream flow for ground water recharge. The Board estimated that an average of ten million gallons of water per day could be conserved by diverting stream flow into the aquifer rather than letting it run unchecked to the sea. The plans for these dams and tunnels were shelved at the beginning of World War II in favor of the Halawa Valley Project. But as demands on Oahu's water resources increase, the Board should reconsider the feasibility of implementing this series of significant ground water conservation measures. In addition to the three streams mentioned above, the Board should investigate the possibility of damming and diverting other streams as part of a comprehensive resource conservation program.[7]

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[6] Department of Land and Natural Resources, Kohakohau Dam Engineering Feasibility, pp. i-vi.

[7] Chester K. Wentworth, Geology and Ground-Water Resources of the Honolulu-Pearl Harbor Area, Oahu, Hawaii (Honolulu, Hawaii: Honolulu Board of Water Supply, 1951), p. 103.

G. T. Hirashima of the U.S. Geological Survey, has suggested a system of diversion dams and ditches to transport water from streams to recharge areas in the Pearl Harbor watershed. Hirashima maintains that there is a great deal yet to be learned about the potential for ground water recharge on Oahu:

> Practical tests are needed to determine the advantages and disadvantages of different types of recharge structures, such as a reservoir or basin, large diameter deep shafts, deep wells, or combinations of all these structures.[8]

The Board of Water Supply's Reservoir Number 4 in Nuuanu Valley is no longer used for domestic water supply. Since the reservoir has a high seepage rate, it acts as a ground water recharging facility. But the recharge from several leaky reservoirs in Nuuanu is an incidental contribution to water conservation. It falls far short of the planned approach to the research and development of recharge facilities that the Board of Water Supply will have to undertake in order to continue to meet the needs of Oahu's water users.

Water resources planners are discussing the concept of building a dam across the West Loch of Pearl Harbor in order to impound the waters of Waikele Stream. The Pearl Harbor Region is bounded to the south by Halawa Valley, to the east by the Koolau Mountains, to the north by the Wahiawa-

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[8] G. T. Hirashima, Availability of Streamflow for Recharge of the Basal Aquifer in the Pearl Harbor Area, Hawaii (Washington, D.C.: U.S. Geological Survey, 1971), p. B2.

Schofield area, and to the West by the Waianae Mountains. The Region is one of the most extensively developed ground water basins in the State.[9] There are three primary sources of demand on the ground water supply of the Pearl Harbor Region: agricultural use, urban use and spring discharge. The following chart shows changes in the ground water discharge rate from 1931 to 1965:

	(millions of gallons per day)		
	1931-32	1964-65	Change
Agricultural use:	170	140	-30
Urban use:	10	50	+40
Spring Discharge:	70	60	-10[10]

The U.S. Geological Survey estimated that of the 170 mgpd of water used for irrigation, 40 mgpd would infiltrate the earth and recharge the ground water supply. With irrigation down to 140 mgpd in 1965, the amount of water returning to the basal supply declined by 10 mgpd. Over all, the net effect of changes in agricultural and urban use, and spring discharge, amounted to an increase of 10 mgpd in demand on the Region's ground water supply.[11]

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[9] Daniel Lum, "Water in the Pearl Harbor Region," address to the Water For Hawaii Conference, January 31, 1974.

[10] R. H. Dale, Land Use and Its Effect on the Basal Water Supply, Pearl Harbor Area, Oahu, Hawaii, 1931-65 (Washington, D.C.: U.S. Geological Survey, 1967). The entire report is relevant in this context.

[11] Ibid.

The Board of Water Supply's 1973 study of the hydrologic conditions in the Pearl Harbor Region indicated that the decline in agricultural use noted by the Geological Survey has leveled off since 1965, and can be expected to remain fairly constant for the remainder of the Twentieth Century. The 1973 study confirmed the accelerating urban use trend observed by the Geological Survey. John Y. C. Chang of the Board of Water Supply's Planning, Resources and Research Division stated in the 1973 study that the ground water situation in the Pearl Harbor Region has become critical:

> The hydrologic balance in the Pearl Harbor region is unfavorable for continued expansion of ground water development over and above what has been committed or planned for the immediate future. Continued expansion of development could lead to serious problems in the area of water quality degradation. Further water development must be at the expense of current users or new sources from other areas must be brought in.[12]

The City and County Department of General Planning has projected a population range from about 1,250,000 people to as many as 2,000,000 by the year 2000. The State Department of Planning and Economic Development's projection anticipates a population of 990,000 people on Oahu at the end of the century. In December, 1974, the State Land Use Commission rezoned 940 acres of Campbell Estate Land at Ewa for urban use. The granting of that rezoning, and the denial of rezoning applications in Windward Oahu, has the net effect of directing growth toward the Pearl Harbor region.[13]

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[12] John Y. C. Chang, Preliminary Report: A Study of West Loch Impoundment (Honolulu, Hawaii: Honolulu Board of Water Supply, November 30, 1973), pp. 1, 4.

The writer hopes that the Land Use Commission understands the consequences of its actions in terms of water resources. One of the responsibilities of a State Environmental Protection Commission, as described in Chapter 6, would be to inform the Land Use Commission about such potentially serious water resource situations as exist in the Pearl Harbor region. It seems clear that if substantial growth is to occur in the Pearl Harbor region, at least one of the following alternatives will have to be taken:

1. Considerable quantities of water will have to be imported from water surplus areas to the Pearl Harbor region (this costly alternative, involving the construction and operation of extensive transmission mains and pumping facilities, is made practically mandatory by the Commission's recent decisions).

2. Leakage from the Pearl Harbor springs could be controlled. The springs discharge approximately 45 mgpd, an amount of water equal to nearly 40% of the amount supplied daily by the Board of Water Supply. Chester K. Wentworth advanced a plan in 1951 for controlling leakage at the Pearl Harbor springs and using basal tunnels (as at the Halawa Valley Project) to develop an amount of high quality water equivalent to the amount saved by repairing the springs. Wentworth was convinced of the feasibility of constructing "cut-off structures" at the face of the major springs and joining these structures by a system of tunnels from which water could be drawn.[14]

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[13] Donald Wolbrink, "Land--The Pearl Harbor Region," address to the Water For Hawaii Conference, January 31, 1974; Honolulu Advertiser, December 21, 1974, p. A3.

[14] Geology and Ground-water Resources of the Honolulu-Pearl Harbor Area, Oahu, Hawaii, pp. 103-04.

3. Treated sewage effluent from the proposed Honouliuli Sewage Treatment Plant could be exchanged for quantities of potable water now being used for irrigation by the Oahu Sugar Company (aspects of this alternative were discussed in Chapter 8).

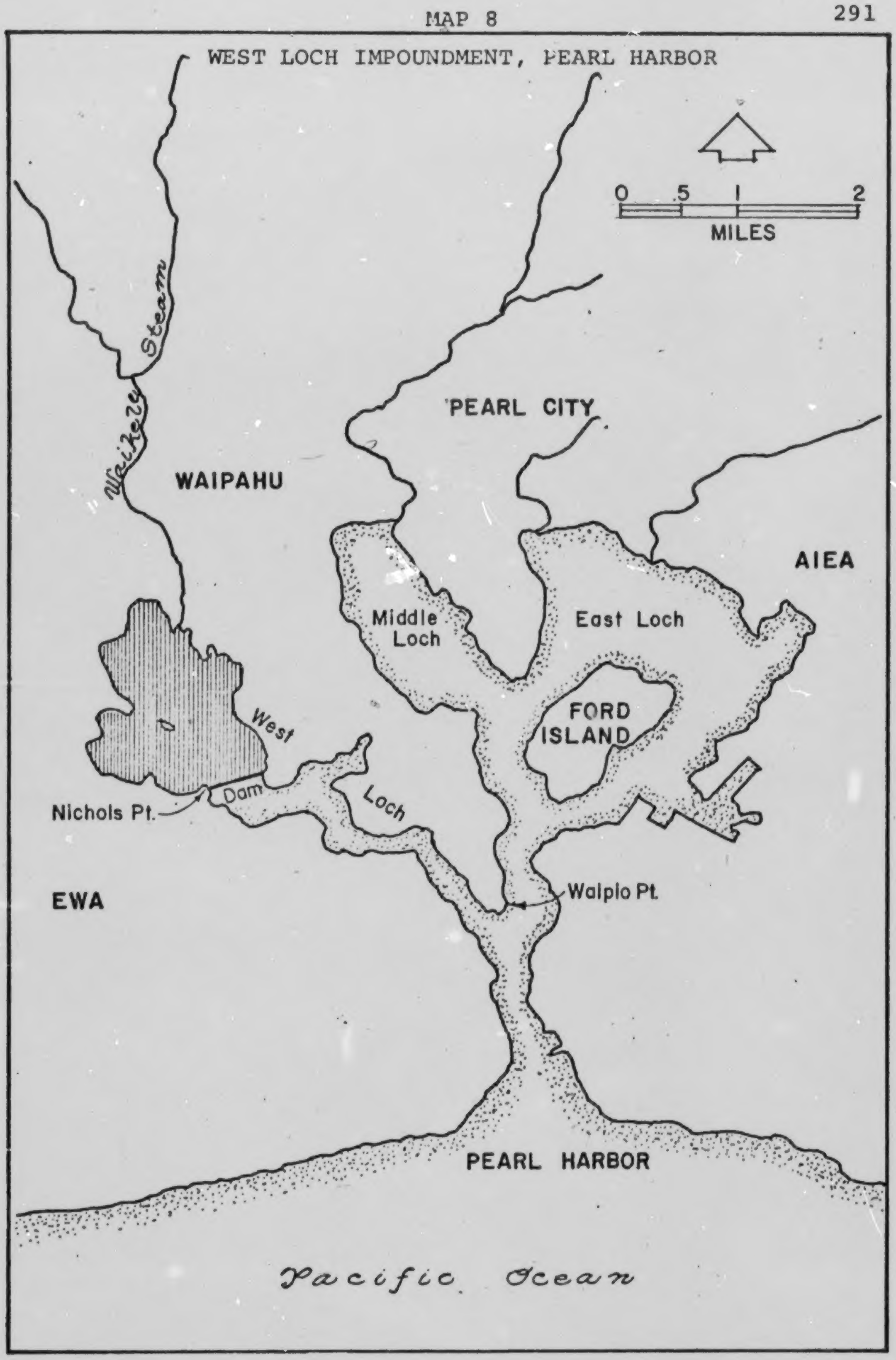
4. Water impounded at West Loch, Pearl Harbor, could be exchanged for potable water now being used by the Oahu Sugar Company.

The Board's policy has been to develop well fields in the Pearl Harbor region, that is, to "dig more holes." In view of the overdraught on the region's water resources, and the prospects for greater demands in the future, the Board is going to have to examine the costs and benefits involved in each of the above alternatives. The Board took a major step toward evaluating the impoundment alternative by authorizing its Planning, Resources and Research Division to undertake a study of impoundment at West Loch in 1973. The study notes that Waikele Stream, with a mean daily flow of about 30 mgpd, empties into West Loch as shown in the following map.

The study postulated the construction of a 2,700 ft. dam to close off the northern half of West Loch. The salt water in the reservoir north of the dam would be pumped out and replaced by fresh water flowing in from Waikele Stream. In time, the impounded fresh water could be used for sugar cane irrigation, and the Oahu Sugar Company might be persuaded to give up its rights to an equivalent amount of

MAP 8

WEST LOCH IMPOUNDMENT, PEARL HARBOR


0 .5 1 2
MILES
Waikele Stream
PEARL CITY
WAIPAHU
AIEA
Middle Loch
East Loch
FORD ISLAND
West
Loch
Dam
Nichols Pt.
Walpio Pt.
EWA
PEARL HARBOR
Pacific Ocean

potable water.[15] It should be noted in passing that the State of Hawaii has certain powers which could very well persuade a private entity to enter into a water exchange agreement. As described in Chapter 2 of this dissertation, Hawaii's Ground Water Use Law, Chapter 177 of the Hawaii Revised Statutes, grants the Board of Land and Natural Resources the authority to designate ground water areas for regulation and control when any of the following conditions exist:

1. The use of ground water exceeds the rate of recharge.
2. Ground water levels are declining.
3. Chloride content of the water is increasing to a level that reduces the value of the use to which water is being put.
4. Excessive preventable waste is occurring.
5. Any water developments are proposed which, in the opinion of the Board, would lead to one of the above conditions.[16]

Quite clearly, the Pearl Harbor region is a potential candidate for becoming the State's first designated ground water area. The existence of Chapter 177 ought to provide the State's water resource managers with a certain amount of leverage in any negotiations with private water users in the Pearl Harbor region.

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[15] Preliminary Report: A Study of West Loch Impoundment, pp. 11-13.

[16] Hawaii, Revised Statutes, Chapter 177.

Questions of negotiations and exchange aside, the Board's 1973 study indicated that given the characteristics of Waikele Stream and West Loch, construction costs for impoundment would be prohibitively high. The cost of building the impoundment dam and intake facilities would be in the neighborhood of 20 to 24 million dollars, and this estimate excludes transmission mains. Since the project would provide only 15 to 20 mgpd of water for irrigation, the study determined that cost factors "render the entire (impoundment) concept marginal at best."[17]

The study compared estimated operating costs for the impoundment project with the costs estimated for producing treated effluent from the Honouliuli Sewage Treatment Plant and found that treated effluent could be delivered to the cane fields for about one fifth the unit cost of impounded water.

Although treated effluent emerged from the study as the leading potential source of irrigation water in the Pearl Harbor region, the Board began preliminary meetings with representatives of the U.S. Navy and Army Engineers in January, 1975, to discuss impounding Pearl Harbor water.[18]

Catchments are another method of conserving surface waters. Although catchments do not have the potential for water resources conservation on Oahu that reservoirs and impoundment may have, they can help meet local water supply needs. There are two general types of catchments: rooftop catchments for individual homes, and ground-level basins lined with asphalt or other material and designed to catch and retain rainfall. There are several hundred rooftop catchments in use on the Big Island, especially along the Kona Coast. There are also about eighty rooftop catchments installed on residences in the Tantalus area of Honolulu, and catchments can still be found in rural Oahu. The experience on the Big Island is that catchments are satisfactory except when there is no rainfall for a period of days. During prolonged droughts, home owners abandon their catchment systems in favor of water from municipal mains when municipal water is available. There is also a potential health hazard from the contamination of these tiny water supply systems.

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[17] Preliminary Report: A Study of West Loch Impoundment, pp. 18, 23 and Foreword.

[18] Honolulu Board of Water Supply, B.W.S. Weekly News Summary, Vol. 3, No. 1 (Honolulu: Honolulu Board of Water Supply, January 17, 1975), p. 4.

Between 1959 and 1961, the U.S. Geological Survey experimented with a large rainfall catchment basin at Waiaha on the Kona Coast, Hawaii. A bulldozer was used to clear an oval shaped rainfall catchment area 210 feet long by 120 feet wide. After clearing, the soil was sprayed with a sterilant to retard plant growth. Then the catchment area was sprayed with asphalt to an average thickness of about one-half inch. When completed, the catchment was capable of storing 240,000 gallons of rain water. The purpose of the experiment was to determine the effect of the passage of time on the catchment's efficiency as a water storage basin. The experimenters measured the ratio of runoff to rainfall, and determined that, due to the deterioration of the asphalt membrane, efficiency fell from 93% in 1959 to 78% in 1961.[19]

The U.S. Geological Survey estimated that the cost of water developed by the Waiaha catchment would be about $1.30 per 1,000 gallons. The researchers suggested that this high unit cost could be reduced by constructing a larger catchment area, and by providing better maintenance of the asphalt membrane.[20]

Asphalt is only one option for covering catchment areas. Aluminum sheeting, polyethylene, vinyl or other plastics could be feasible construction materials. There has been no systematic study of how these materials would perform under Hawaiian conditions. One of the problems involved in building rainfall catchments on Oahu is that any catchment large enough to yield significant quantities of water would be expensive simply from the standpoint of land use. In the opinion of the writer, the construction of catchments on Oahu must be considered a relatively low priority water conservation measure.

A discussion of surface water conservation leads invariably to a consideration of ground water conservation simply because waters are in motion. Waters that begin as runoff and stream flow infiltrate the earth to become ground waters, and may emerge once again as spring flow. With these properties of water in mind, the writer has already considered ground water recharge through the use of diversion dams and infiltration tunnels, and also the use of reservoirs for ground water conservation. Ground waters may also be recharged with treated sewage effluent. The use of waste water for the replenishment of the underground water supply has been a standard procedure for several California communities for many years. The preliminary findings of the Mililani study on the use of treated effluent for irrigation indicate that there is real potential for ground water recharge by treated waste water on Oahu (see Chapter 8). There would be many opportunities for innovative engineering if waste water were accepted for ground water recharge on this Island.[21]

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[19] Salwyn S. W. Chinn, Water-Supply Potential From an Asphalt-lined Catchment near Holualoa, Kona, Hawaii (Washington, D.C.: U.S. Geological Survey, 1965), pp. P1, 2, 5, 13, 20.

[20] Ibid., pp. P23, P24.

Proposals to control leakage at the Pearl Harbor springs can also be classified as ground water conservation measures because the elimination or control of this leakage would result in an increase in the thickness of the basal fresh water lens. Another ground water conservation technique is the sealing or repair of defective artesian wells. Honolulu's municipal water supply managers carried out a major conservation effort involving the location and sealing of lost and defective artesian wells in the late 1920's and early 1930's. The Board of Water Supply still regulates the construction and operation of artesian wells, and occasionally seals them as a water conservation measure. The Board has published a pamphlet entitled, Rules and Regulations for the Protection, Development and Conservation of Water Resources, and has made it readily available to the public. The pamphlet explains the Board's regulatory authority with regard to artesian wells, waste disposal facilities, pesticide use, and the protection of water resources in general.

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[21] "Water Reuse for Public Water Supply."

In Chapter 8, drip irrigation was considered in the context of water recycling and treatment. Drip irrigation may also have considerable potential in terms of water resource conservation. Agriculture is Oahu's major water user, and the irrigation of sugar cane accounts for the largest share of agricultural water use. Drip irrigation provides high water use efficiency. Water is applied directly to the soil containing the roots of the sugar cane plants. Water does not infiltrate deeply into the soil as in furrow irrigation, nor is it subject to wind conditions as with sprinkler irrigation.[22]

The following chart indicates irrigation water efficiency (the ratio between water available to the roots of the plant, and total water applied) for drip, sprinkler and furrow irrigation:

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[22] John T. Humme, "Water Use by Agriculture," address to the Water For Hawaii Conference, January 31, 1974; John W. Hoxie, "What Happens if Drip Irrigation is Implemented?" address to the Water For Hawaii Conference, January 31, 1974.

Drip:	80%
Sprinkler:	65 to 75%
Furrow:	30 to 40%[23]

As drip irrigation techniques are perfected, the system's water efficiency is expected to exceed 85 percent.[24] Drip irrigation saves water. But the broad application of drip irrigation technology will probably not cause a dramatic change in water resource use on Oahu. One consideration is that conventional furrow irrigation provides significant recharge to the underground water supply. Depending on soil conditions and geological factors, about 25 percent of the water applied in furrow irrigation infiltrates the substrata and contributes to the basal lens. In drip irrigation systems, there is practically no deep infiltration of irrigation water. The writer believes that trends in land use designation are a more significant factor in water resources conservation than changes in irrigation practices.

There are opportunities for water conservation within the Board's own supply system. The Board pumps an average of 122 mgpd through its distribution system. But billing records show that approximately 16 mgpd of this water is lost, or unaccounted for. Water may be unaccounted for due to the flushing of water mains, fire-fighting, street cleaning, the flushing of the sewer system, and because of broken and leaking mains. The Board's percentage of unaccounted for water (13% of total distribution), is well within the range generally experienced by other major water utilities. Nevertheless, Manager and Chief Engineer Edward Hirata, has been concerned about the quantity of water being lost through undetected leaks in water mains. Mr. Hirata authorized the Operations Division to conduct a thorough review of leak detection techniques and the companies offering leak detection services. On the basis of this review, Mr. Hirata asked the Board to hire the Hydrotronic Corporation of America to investigate and locate leaks in the Board's distribution system. The Board appropriated $23,000 for the leak detection service. The Board was motivated by a desire to conserve water resources, and reduce operating expenses. It costs the Board approximately $.12 to produce 1,000 gallons of water. If the leak detection service could reduce unaccounted for water by 1 mgpd, the annual savings to the Board and its water customers would be about $43,800.[25]

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[23] *Hydraulics, Mechanics and Economics of Subsurface and Drip Irrigation of Hawaiian Sugarcane*, p. 2.

[24] Hannibal Tavares, "What Water Means to Alexander & Baldwin, Inc.," address to the Water For Hawaii Conference, January 31, 1974.

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[25] Francis Lee, official correspondence with Hydrotronic Corporation of America, Pitometer Associates, and several municipal water utilities; Edward Hirata, memorandum to the members of the Board of Water Supply regarding leak detection. Approximate date: August 1, 1974.

The Hydrotronic Corporation's leak detection technique makes use of ultrasonic sensing equipment to detect and magnify the sound of water escaping through ruptured pipe. This highly sophisticated technique is consistently able to find leaks as small as 3/64" and pinpoint their location within a one foot radius.[26]

Under the terms of Hydrotronic's contract with the Board, the company agreed to examine what was believed to be the worst 110 miles of the Board's 1,500 mile distribution system. In January, 1975, Mr. Hirata announced the results of the examination to a meeting of the Hawaii Society of Professional Engineers: Hydrotronics had located 26 leaks which were losing about 134,000 gallons of water per day.[27]

The writer has examined reports of the results of Hydrotronic Corporation's operations in Honolulu, and will recommend that the Board authorize the firm to examine another 110 miles of the distribution system.

Another source of unaccounted for water is water used for the training of fire fighters. Ever since the early 1930's, when Frederick Ohrt was Manager and Chief Engineer, the Board of Water Supply has been trying to retrieve some of the expense it incurs when it provides water to the Fire Department for fire-fighting and training. This reimbursement question has never been resolved, and the Board has been providing "free water" to the City and County for fire-fighting purposes. The Fire Department uses about 350,000 gallons of water per month for training purposes. Each of the Department's 35 engine companies holds a "wet drill" once a month. In September, 1974, the Board received assurances from the Fire Department that the Department would look into some method, such as metering, that would accurately determine the amount of water used for training purposes. The measurement of this water is a step toward accountability and water conservation.[28]

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[26] Hydrotronic Corporation of America, Hydrotronic (Miami, Florida: Hydrotronic Corporation of America). Pamphlet.

[27] Edward Hirata, address to the Hawaii Society of Professional Engineers, Honolulu, Hawaii, January 28, 1975; Robert T. Kagamida, "Hydrotronic Report" (Honolulu, Hawaii: Honolulu Board of Water Supply, February 12, 1975). (Mimeographed.)

For the great majority of Oahu's people, water resource conservation is not a matter of watershed management, or recharge, or leak detection; water conservation begins and ends in the home. There are really two aspects of household water conservation. One aspect involves the consciousness, or awareness, of the water user. And the second concerns the improvement and the availability of water saving devices for the home. The following chart shows how water is used in the home on a national basis:

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[28] Harry D. Holt, memorandum to Edward Hirata, subject: Water used for fire training, September 16, 1974.

Use Category	Percent
Toilet Flushing	27-45
Bathing	18-36
Laundering	18
Kitchen	13
Lavatory	4
Utility	2[29]

It is estimated that Hawaii residents use proportionately more household water for bathing and laundering than do mainland residents. This is probably due to cultural and climatic factors.

In 1971, the Environmental Protection Agency funded a study of devices that promote water conservation in the home. One technique involved the recycling of bath water for toilet flushing. Less elaborate techniques consisted of installing shallow-trap and water saving toilets, and flow-reducing shower heads. The EPA reported the following results:

Unit Tested	% Reduction in Total Household Water Use
Water recycling system	27.0
Shallow-trap and water saving toilets	3.3 to 8.6

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[29] H. Wallman, "Should We Recycle/Conserve Household Water?" Paper presented at the 6th Annual Water Quality Symposium, Washington, D.C., April 18-19, 1972.

Flow-reducing shower heads	1.0[30]

The researchers conducted a user survey to determine the degree of acceptance of the various devices:

Unit	Percentage Acceptance
Water recycling system	50-67
Shallow-trap and water saving toilets	83-100
Flow-reducing shower heads	88[31]

Although the sample in the EPA study was small (only eight households), the results were encouraging in terms of water conservation and public acceptance of conservation devices. In 1972 the Washington Suburban Sanitary Commission conducted tests of water saving devices in 2,400 homes. The flow-reducing fixtures included pressure reducing valves which lowered household water pressure from about 60 pounds per square inch (psi) to 50 psi, flow-reducing shower heads and toilet inserts. The results of the tests were quite positive: household water use was reduced by 30 percent. The results of the study were convincing enough to influence the passage of new plumbing codes requiring reduced-flow fixtures for new construction and remodeling. As part of its conservation program, the Washington Suburban Sanitary Commission is distributing water saving kits containing a booklet on water saving, dye tablets for tracing toilet tank leaks, and plastic bottles to be inserted in toilet flush tanks to its customers in suburban Washington, D.C.[32]

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[30] S. Cohen and H. Wallman, Demonstration of Waste Flow Reduction from Households, Environmental Protection Agency Project 11010 GXJ.

[31] Harry E. Bostian, "Conserving Water At Home," News of Environmental Research in Cincinnati (Washington, D.C.: U.S. Environmental Protection Agency, November 9, 1973), pp. 1-4.

A recent study by two independent researchers writing in the Journal of the American Water Works Association concluded that currently available household water saving devices permit a reduction of up to 32 percent in home water use. These writers pointed out that at the present time there are few incentives for household water conservation. But they predicted that as water costs rise, and as the public becomes more concerned with matters of water supply, the incentives to use water saving devices will increase.[33]

Water saving devices are only one aspect of household water conservation. The other component is public awareness of the need for water conservation in the home. On a broad scale, the American people are becoming conscious of the finite nature of most resources. This awareness of environmental limits is going to be reflected in the way people live; people are going to accept conservation as a routine part of their lives. Water resource managers can operate within this society-wide context to inform people about the vital importance of water, the finite quality of water resources, and the need to practice water conservation as a matter of course. This public information effort can proceed at two levels: one level involves general public awareness of the water resources they use and the water supply system that provides them with water. An example is the annual "Water Week" program established for the public by the Honolulu Board of Water Supply. The program features informational tours of the Board's Engineering Building and the underground shaft at Halawa Valley. At a more specific level, water supply utilities should provide their customers with information about the need for conserving water in their community, and it should provide them with specific steps to take toward conserving water in their homes.

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[32] Washington Suburban Sanitary Commission, Final and Comprehensive Report, Cabin John Drainage Basin Water-Saving, Customer Education and Appliance Test Program (Hyattsville, Maryland: Washington Suburban Sanitary Commission, February, 1973); Washington Suburban Sanitary Commission, It's Up To You! A Customer Handbook on Water-Saving and Waste-Water-Reduction (Hyattsville, Maryland: Washington Suburban Sanitary Commission, 1972). Pamphlet.

[33] Charles W. Howe and William J. Vaughan, "In-House Water Savings," Journal of the American Water Works Association (February, 1972), pp. 118-121.

In 1973, the Board of Water Supply began a public education program entitled, "How to Save Water by Really Trying." As part of this program, the Board sent its customers two pamphlets intended to introduce the public to household water conservation. The pamphlets offered specific suggestions about how to save water in each of the following categories:

Bathing
The Toilet

Lawn and Garden Care

Car Washing

Cooking

Dishwashing

Garbage Disposal

The Home Laundry[34]

The Board's household water conservation program was aided in February, 1975, when the first issue of the *Honolulu Newsletter* carried advice on water conservation and six relatively simple steps that would contribute to water conservation in the home. The *Newsletter* is published by the City and County, and is being distributed initially to 3,000 opinion leaders in business, government and education on Oahu.[35]

Water resource conservation affects both the supply and the demand sides of the water use equation. Effective watershed management, ground water recharge, impoundment and leak detection augment the supply of water. Improved irrigation techniques, water recycling and household conservation programs help reduce the demand on that finite supply. It is not enough to increase supply into the indefinite future. The costs become prohibitive. If the Board is to continue to supply an ample quantity of water at a reasonable price, the people of Oahu will have to accept limits on their water requirements.

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[34] Honolulu Board of Water Supply, *How to Save Water by Really Trying: Part 1* (Honolulu, Hawaii: Honolulu Board of Water Supply, February, 1973); Honolulu Board of Water Supply, *How to Save Water by Really Trying: Part 2* (Honolulu, Hawaii: Honolulu Board of Water Supply, April, 1973). Both publications are pamphlets.

[35] City and County of Honolulu, *Honolulu Newsletter*, Vol. 1, No. 1 (Honolulu, Hawaii: City and County of Honolulu, February, 1975), pp. 1-4.

Chapter 10

ENERGY

Energy is becoming a matter of vital concern for water supply professionals on the Island of Oahu. The Honolulu Board of Water Supply requires the expenditure of a great deal of electrical energy in order to provide water to the people of Oahu. Energy is necessary to raise water from the basal lens and pump over 120 million gallons of water per day through the 1,500 miles of water mains that comprise the Board's distribution system. The following chart shows the Board's expenditure (or anticipated expenditure) for energy for Fiscal Years 1973 through 1975:

Electric Power Expense	
1973:	$1,191,621
1974:	1,353,338
1975:	1,734,330[1]

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[1] Honolulu Board of Water Supply, 1974-75 Budget (Honolulu: Honolulu Board of Water Supply, May, 1974), p. 81. The amount anticipated for F.Y. 1975 represents an increase of 28.15% over the previous year. Barry M. Suyemoto, Waterworks Controller, reported on March 5, 1975, that the Board is consuming approximately 5,709,700 Kilowatt hours of electricity per month.

An examination of the Board's 1974-75 Budget shows that the cost of electrical power is by far the costliest item in the Operations Division's "Materials, Supplies and Services" expenditure classification. The Operations Division spends more money on only one other expense item: the salaries of its 393 employees.[2]

The Board's second largest energy expense item is the money required to keep the Board's fleet of 223 trucks, cars and other vehicles on the road. The following chart shows gasoline expenses (actual or estimated) for F.Y. 1973 through 1975:

	Gasoline Expense
1973:	$61,782
1974:	77,200
1975:	78,500[3]

The magnitude of the Board's electric power costs is indicated by the fact that gasoline to keep the Board's 223 vehicles in operation costs only about 5% of the amount expended to meet the Board's requirements for electrical energy.

The Board of Water Supply has yet to carry out a detailed study of the relationship between energy (costs and availability) and the Board's water supply capability. The writer hopes that this chapter (which will be brought to the attention of the members of the Board and the Planning, Resources and Research Division) will focus attention on the costs and availability of energy on Oahu.

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[2] Ibid., pp. 81-120.

[3] 1974-75 Budget, p. 83; 1973 Annual Report, p. 3.

The remainder of this chapter will be devoted to three aspects of the energy situation:

1. The national debate over energy policy.
2. Hawaii's search for alternative energy sources.
3. Energy and the future of water supply on Oahu.

Until 1973, American society had been accustomed for many decades to a plentiful supply of inexpensive energy. But in the autumn of 1973, the Arab oil producing states imposed an embargo on petroleum shipments to the industrialized nations of the West. The embargo lasted for five months, and it precipitated the energy crisis of the winter of 1973-74. During the eighteen month period from July, 1973, to January, 1975, the price of petroleum on the world market quadrupled to approximately $10.50 for a 44 gallon barrel of petroleum. Gasoline prices and electricity rates practically doubled in the United States during that period.

To a considerable extent, the oil embargo caught the United States unprepared. The nation grappled with its energy problems throughout 1974. In January, 1975, President Ford announced his energy proposals to Congress and to the American people. The purpose of his program was to make the United States independent of oil exporters by 1985. The President offered four major proposals:

1. The construction of 200 major new nuclear power plants by 1985. At present, the United States has 53 nuclear power plants in operation, with another 63 under construction.
2. The opening of 250 major new coal mines, and 150 new coal-fired power plants.
3. The construction of 30 new oil refineries, and the building of storage facilities for an emergency supply of 1.3 billion barrels of oil.
4. The imposition of a $3.00 per barrel fee on imported oil by April 1, 1975. This measure would force an increase in the price of gasoline. The President views this price increase as a conservation measure and an alternative to gasoline rationing.[4]

At this writing, Congress is expected to offer its own package of energy proposals. There is a good deal of dissatisfaction on Capitol Hill with the President's decision to impose a $3.00 per barrel surtax on imported oil. The surtax is expected to contribute to inflation at the very time when national leaders and economists are trying to bring prices under control. The President's surtax is expected to add $.15 to the price of each gallon of gasoline, and although the price increase will contribute to conservation, it will impose a heavy burden on the American public.

The President is calling for the construction of nuclear power plants at an unprecedented rate. Yet there is widespread concern that nuclear power plants are unsafe. In

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[4] Gerald Ford, State of the Union Address, Washington, D.C., January 15, 1975, reprinted in the Honolulu Advertiser, January 16, 1975, pp. A1, A4.

January, 1975, the Nuclear Regulatory Commission ordered the shutting down of 23 nuclear facilities after cracks were discovered in the emergency cooling system of a reactor operated by Commonwealth Edison Company at Morris, Illinois.[5]

The President's proposal to build one hundred and fifty new coal-fired power plants increases utilization of the nation's most abundant energy resource. But a decision to mine and burn more coal is bound to have a detrimental effect on the national effort to combat the deterioration of air quality. In effect, the President told Congress in his State of the Union Message that energy independence must be considered a higher priority than environmental protection.

The President's proposed $3.00 per barrel surtax on imported oil could impose a special hardship on the State of Hawaii. Nationally, approximately 20% of all electricity is generated by oil, while Hawaii is almost entirely dependent on this energy source. Senators Hiram L. Fong and Daniel K. Inouye have pledged that they will work for some kind of exemption for Hawaii if the surtax is adopted by Congress. Governor Ariyoshi has dispatched representatives of the State's Department of Planning and Economic Development to Washington to meet with Federal energy officials and point out Hawaii's exceptionally vulnerable energy situation.

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[5] Honolulu Star-Bulletin, January 30, 1975, p. A7.

Over 99% of the electrical energy sold by the State's utilities is derived from the burning of petroleum that is brought to the Islands on ocean-going tankers. The burning of bagasse (the fibre of sugar cane stalks) and hydroelectric power together constitute less than one percent of the energy distributed by utilities throughout the Islands. The Island of Oahu is 100% dependent upon seaborne petroleum.[6]

[illegible]g the energy crisis of the winter of 1973-74, Acti[illegible]ernor (now Governor), George Ariyoshi, appointed a Sta[illegible]e Advisory Task Force on Energy Policy to formulate a Statewide response to the energy situation. The Task Force developed Gasplan, an equitable and successful fuel rationing program, and other conservation measures. The Task Force also established a Committee on Alternate Energy Sources for Hawaii to examine energy resources that might provide Hawaii with alternatives to seaborne petroleum. The 78 member Committee examined and rated ten possible energy sources:

1. Solid Waste
2. Bioconversion.
3. Hydroelectric Power.
4. Wind.
5. Geothermal Energy.

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[6] Robert T. Chuck, et al., Status Report of the Hydroelectric Power Task Force, Alternate Energy Sources For Hawaii Committee (Honolulu, Hawaii: November, 1974). The pages of this report are not numbered. (Mimeographed.)

6. Solar Collectors.
7. Ocean Thermal Energy Conversion.
8. Waves, Tides, Ocean Currents, Osmosis.
9. Coal.
10. Nuclear Power.[7]

After eight months of extensive review and analysis involving 78 members of the Committee, two major conclusions emerged as part of a general consensus:

1. No short-term substitutes for oil can be introduced to Hawaii that will have a major impact on reducing the State's near total dependence on seaborne petroleum. This includes indigenous natural energy resources, coal, and nuclear power. Although coal is receiving strong support at the national level as a substitute for petroleum products, there is little likelihood that coal could be introduced to Hawaii within the next ten years in sufficient quantities--either in granular or liquified form--to have significant effect on the State energy supply.
2. There are a number of indigenous renewable natural energy resources that show excellent potential for meeting a significant percentage of Hawaii's future energy needs. The State should continue with the establishment of policy and institutions, including a reasonable level of research and development funding, to verify the potential of these natural energy resources and to develop those which prove to be technically, environmentally, and economically feasible.[8]

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[7] John W. Shupe, "Alternate Energy Sources for Hawaii," paper presented to the Committee on Alternate Energy Sources for Hawaii, Honolulu, Hawaii: August 1, 1974.

[8] Committee on Alternate Energy Sources for Hawaii, "Overview and Recommendation," Honolulu, Hawaii: February, 1975. The pages of this report are not numbered. (Mimeographed.)

The Committee summarized its findings with regard to each of the ten potential energy resources as follows:

Solid Waste: The use of combustible municipal refuse as an energy resource has real potential for Hawaii. The State produces 650,000 tons of combustible municipal refuse annually (85% of it on Oahu). Although the fuel for this energy resource is "free," the equipment necessary to convert municipal solid wastes to useful energy requires considerable capital investment. The process has some negative impacts on the environment, but these are thought to be acceptable because the use of municipal wastes as an energy source diminishes the need for land fills and other disposal systems.

The City and County of Honolulu, in cooperation with Amfac and the Hawaiian Electric Company, is carrying out a feasibility study on resource recovery from solid wastes. The Committee recommends that this program be continued, and that other counties initiate similar studies.[9]

Bioconversion: Plant cellulose can be converted to liquid or gaseous fuels. Considerable research is being carried out in the United States on processes designed to convert plant fibre into methane and alcohols.

At the present time, Hawaii's sugar mills are fueled almost entirely by bagasse. Although energy from this source is utilized on the plantations and is not sold commercially, it constitutes a significant 8% of the State's total energy use.

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[9] Committee on Alternate Energy Sources for Hawaii, "Task Force Summaries and Conclusions," Honolulu, Hawaii: February, 1975, pp. 24, 25.

The leaves of sugar cane harvested each year contain about 1.8 million tons of dry matter. This "cane trash" is usually burned in the field, or discarded at the mill. However, cane trash has the potential to provide an additional 8% of the State's energy needs. The first power plant to use cane trash as fuel is already in operation at Pepeekeo on the Island of Hawaii. The plant has the capacity to provide one half of one percent of the State's energy needs. The Committee on Alternate Energy Resources recommends a detailed review of the economic and environmental ramifications of using cane trash as a supplementary energy resource.[10]

Hydroelectric Power: Hydroelectric power is a limited, but readily available energy source of Hawaii. At the present time, hydroelectric power constitutes 0.4% of the State's commercially generated electrical energy, and about 2% of the State's total electrical demand when the energy generated and utilized by sugar plantations is taken into account.

Hydroelectric energy is potentially capable of providing about 6% of the State's total energy needs by the year

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[10] H. P. Kortschak, "Bioconversion," Honolulu, Hawaii: Hawaiian Sugar Planters' Association, October 30, 1974. This report is in draft form. Pages are not numbered. (Mimeographed.)

1990. For specific islands, hydroelectric power could be quite important. On Kauai, for example, it could supply as much as 30% of the electrical power needed by 1990.

Hydroelectric power enjoys some major advantages. The technology is fully developed and plants could be designed and built using available data and specification. In addition, hydroelectric plants do not deplete natural energy reserves, and they do not produce any toxic substances that might degrade the environment.

As far as costs are concerned, hydroelectric power is becoming increasingly competitive with power generated from fossil fuels. As fossil fuels become increasingly scarce, hydroelectric power can be expected to attain an economic advantage over fossil fuels.

The Committee on Alternate Energy Sources has recommended expanded engineering studies on specific sites for hydroelectric plants, especially on the Island of Kauai. Moreover, the Committee has advised the State to develop cost estimates and time schedules for the construction of hydroelectric power plants.[11]

Wind: Wind has excellent potential for providing a significant share of Hawaii's future energy requirements. Oahu is especially favored in this respect because the Island has about 50 miles of mountain crests athwart the trade winds. The trades blow from the northeast at average velocities of from 10 to 15 miles per hour. Since the trades are not constant, energy storage facilities will have to be used during calm periods and during periods of Kona weather (Kona winds come out of the southeast, and usually bring stormy weather).

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[11] Committee on Alternate Energy Sources for Hawaii, "Task Force Summaries and Conclusions," pp. 28, 29.

Nobel Prize-winning physicist Dr. Edward Teller has agreed to serve as an energy consultant on wind power to the City and County of Honolulu. Dr. Teller envisions a string of 1,000 windmills installed along the windward ramparts of Oahu, and generating enough energy to supply nearly all of the Island's needs. Dr. Teller estimated that the cost of the entire system would approach one billion dollars. However, once the generating machinery is operating, the wind would be a constantly renewable source of free energy. If the project were carried through to completion, Oahu's total dependence on increasingly costly and potentially unreliable seaborne petroleum would be a thing of the past.[12]

The Center for Engineering Research at the University of Hawaii, in cooperation with the City and County of Honolulu, has carried out a preliminary feasibility study of wind velocities and wind patterns on Oahu. The study indicated that the 15 mph wind velocity threshold considered necessary to make wind power feasible is attained from 60 to 70 percent of the time in the Nuuanu Pali area. Plans are underway to expand this preliminary study and to design and build a major windmill installation on Oahu. The cooperative program involves the State, the City and County, the University and the Hawaiian Electric Company.

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[12] Interview with Dr. Edward Teller reported in the Honolulu Employee Journal, January, 1975, published by the Department of Civil Service, City and County of Honolulu, pp. 1, 4.

Wind power is a renewable natural energy resource. It produces no toxic substances, and its only negative impact is visual. However, proper placement and design of the windmill towers can minimize the negative visual impact.

The Committee on Alternate Energy Resources recommends increased support for wind power studies on Oahu, and extension of these studies to other islands having potential for wind energy development.[13]

Geothermal Energy: Geothermal energy is expected to be an important factor in Hawaii's long-range energy situation. In 1973, the National Science Foundation, the State of Hawaii, and the County of Hawaii provided initial funding for the Hawaii Geothermal Project. The Project is investigating the feasibility of developing geothermal energy on the Island of Hawaii. An exploratory drilling program under the direction of the Hawaii Geothermal Project is scheduled to begin in the spring of 1975. Project managers hope to determine whether a commercially viable geothermal field exists in the Puna region of the Big Island, and which of the five following geothermal energy sources are actually present:

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[13] Ibid., pp. 30, 31. "Energy Storage and Transport Systems," a paper prepared for the Committee on Alternate Energy Sources by Paul C. Yuen, October 31, 1974, is especially relevant to energy storage problems on Oahu.

1. geothermal steam
2. hot water
3. molten magma
4. hot porous rock
5. hot dense rock[14]

The technology for utilizing geothermal steam and hot water is well developed, and these sources are considered conventional geothermal resources. But molten magma occurs so frequently on the Big Island that it should be studied as a potential long-term energy resource.

At the present time, the geothermal field at Geysers, California is the only operational field in the United States. Economic comparisons show that energy developed at Geysers is quite competitive with energy developed by the consumption of fossil fuel. In addition, environmental problems associated with the use of geothermal energy are considered relatively easy to solve.

If the exploratory drilling program on the Big Island is successful, the Hawaii Geothermal Project expects to survey other Islands in the Hawaiian chain. If huge reservoirs of energy are found on the Big Island, future technological breakthroughs may make it possible to transmit energy efficiently to the other Islands.[15]

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[14] John W. Shupe, "Overview of Phases I and II: The Hawaii Geothermal Project," Honolulu, Hawaii: University of Hawaii, August 27, 1974. The pages of this report are not numbered. (Mimeographed.)

Solar Collectors: Solar collectors are an attractive energy source for Hawaii because the State enjoys one of the highest annual rates of solar radiation in the nation. An extensive national and international effort is underway to refine solar collectors and improve the technology needed to utilize solar energy.

From the environmental perspective, the advantages of solar energy exceed all other energy sources. Solar energy is entirely non-polluting, and it is a totally renewable resource.

At present, about 25% of the electric power generated in the State of Hawaii is used for domestic water heating and air conditioning. Solar energy collection could be applied in Hawaii to meet these two specific energy demands. The Committee on Alternate Energy Sources recommends that the State encourage the installation of solar collectors in private buildings and homes by means of tax incentives and loans. Furthermore, the Committee recommends that the State require engineering feasibility studies for solar collectors for water heating and air conditioning in new public buildings.[16]

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[15] Committee on Alternate Energy Sources for Hawaii, "Task Force Summaries and Conclusions," pp. 32, 33.

[16] Ibid., pp. 34, 35.

The Honolulu Board of Water Supply has moved into the solar energy field by installing "solar-power energy sub-irrigation systems" at fifteen BWS facilities on Oahu. Each unit collects and stores solar energy, and uses the energy to activate a drip irrigation system. The units are being installed on relatively steep land, where sprinkler irrigation would contribute to runoff and soil erosion. In effect, the units conserve energy by using solar power, they conserve irrigation water, they conserve the soil by preventing erosion, and they prevent pollution of streams and receiving waters by soil runoff.[17]

Ocean Thermal Energy Conversion (OTEC): If OTEC systems become a practical reality, Hawaii could become self-sufficient with respect to energy. The process depends on the presence of cold ocean waters in proximity to warm waters and to land. Ke-ahole Point, on the Kona Coast of the Big Island of Hawaii, is considered an ideal site for ocean thermal energy conversion. Cold waters from the ocean could be pumped to the surface and used in conjunction with warm surface water to create energy for the production of electricity. Whenever a significant temperature differential is available, energy can be extracted with a Rankine cycle engine.[18]

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[17] The Board of Water Supply presented a remarkable demonstration of the solar-power energy sub-irrigation system at the National Energy Week exhibitions at Ala Moana Center and at the University of Hawaii during February, 1975.

The National Science Foundation is considering whether to fund the construction of an OTEC pilot plant at the Ke-ahole Point location. Capital expenses are expected to be much greater for an OTEC facility than for a conventional power plant. But initial costs should be evaluated in terms of OTEC's relatively low operating costs, and its complete independence from any conventional fuel sources. The Committee on Alternate Energy Sources recommends the continuation of the joint effort by the State, the County of Hawaii, the University of Hawaii and private industry to attract OTEC research and a demonstration plant to Hawaii.[19]

Ocean Waves, Tides, Currents, and Osmosis: The conclusion of the Committee on Alternate Energy Sources is that these four energy sources "all have such low energy densities and are so variable in behavior that their collective energy potential is quite low. . . ." The equipment for extracting energy from such low density sources would be extremely large, quite expensive, and--in many cases--environmentally unacceptable. They can be eliminated as serious contenders for supplying power at commercial levels in Hawaii.[20]

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[18] Joe A. Hanson, et al., "Report of the Ocean Thermal Energy Conversion Task Force," Honolulu, Hawaii: October 31, 1974. The pages of this report are not numbered. (Mimeographed.)

[19] Committee on Alternate Energy Sources for Hawaii, "Task Force Summaries and Conclusions," pp. 36, 37.

Coal: The United States has sufficient reserves for over one hundred years at the present rate of consumption. If the necessary decisions were made within the next few years, coal-fired electrical energy could become a reality in Hawaii in the early 1990's. The use of coal as an energy resource would present some major logistics problems for Hawaii: port facilities would have to be built, unloading and storage areas would have to be established, and a surface transportation system to move the coal from dockside to the power plant would have to be put into operation. None of these facilities exist at the present time.

From the environmental perspective, the use of coal requires controls of such unacceptable substances as sulfur dioxide and particulates. In addition, large quantities of ash must be disposed of. The Committee on Alternate Energy Sources concludes that a coal-fired plant could be located either on land or offshore with various economic and environmental trade-offs.

Research programs are underway in the United States to develop combustible bases, liquids and refined solids from coal. If this research is successful, synthetic fuels derived from coal could substantially replace coal and petroleum based fuels. Synthetic fuels would eliminate or minimize many of the logistic and environmental problems associated with burning coal for energy. The Committee advises, however, that it could be as long as ten years before synthetic fuels derived from coal are proven feasible in large scale application, and become commercially available in Hawaii.

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[20] Ibid., p. 38.

The Committee's single recommendation is cautious:

> (The State should) keep informed of all developments relating to the handling of granular coal, liquefaction, and gasification so that any breakthroughs can be considered for application to Hawaii.[21]

Nuclear Power: There have been disappointments in the development of the nation's atomic energy program since 1945, and there are fears that nuclear power installations may be hazardous. But despite these fears and disappointments, the energy stored in the nucleus of the atom still offers the promise of virtually limitless energy for the future. Nuclear energy can be released through fission (the splitting of large uranium atoms into smaller atoms), and fusion (the combining of hydrogen atoms into helium atoms).

The technology for producing power from the fission process is well developed. But commercial production is economical only in very large scale units. The planning and construction of a nuclear power plant takes a minimum of ten years. Moreover, the best estimates are that a nuclear power plant of the smallest available commercial size could not be accommodated within Oahu's electrical distribution system before the year 2000.

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[21] Ibid., pp. 39, 40.

The Committee on Alternate Energy Sources expressed confidence that nuclear power is safe; virtually zero radioactivity is released under normal conditions. In the event of a catastrophic failure, redundant safety systems go into effect to prevent or minimize any radiation discharge into the atmosphere. The writer believes that the United States has demonstrated such technical ability in the development of nuclear submarines that solutions will be found to any potential safety problems in nuclear power plants.

Preliminary indications are that an acceptable site for a nuclear facility can be found on Oahu. The Committee recommends that the State initiate comprehensive seismic and geologic investigations to determine whether potential nuclear plant sites exist on Oahu and the Neighbor Islands.

The disposal of nuclear wastes remains a major environmental problem because of the potency and longevity of certain radioactive by-products of nuclear fission.

The Atomic Energy Commission (succeeded in January, 1975, by the Energy Research and Development Administration) has projected that fusion power plants may become competitive with other energy sources within the next thirty years. This development holds promise for the distant future, but is not expected to have any impact on Hawaii until well after the turn of the century.[22]

Table 2, from the "Overview and Recommendations" of the Committee on Alternate Energy Sources for Hawaii, presents a summary of the Committee's findings.

The Committee on Alternate Energy Sources concluded that a number of indigenous renewable energy resources show excellent potential for meeting a significant percentage of Hawaii's future energy needs. Although these alternate energy sources should have an important role in the 1980's and thereafter, it will take a comprehensive State supported plan to develop these resources. The Committee made a number of specific recommendations intended to enhance the State's ability to respond to future energy needs:

1. The State should provide at least $1,000,000 annually to fund energy research and development projects. Special support should be provided for projects showing the greatest promise, and for projects receiving matching support from the Federal Government.
2. The position of Energy Resources Coordinator should be strengthened in accordance with existing legislation passed by the 1974 State Legislature. The powers, duties and level of support called for in Act 237, Regular Session, 1974, would enable the Energy Resources Coordinator (currently the Director of the Department of Planning and Economic Development) to provide the leadership necessary to develop and implement a long range energy policy for Hawaii.

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[22] "Task Force Summaries and Conclusions," pp. 41, 42; S. F. Tuan, "Nuclear Fusion and the State of Hawaii," a preliminary report to the Committee on Alternate Energy Sources for Hawaii, 1974. (Mimeographed.)

TABLE 2

ALTERNATE ENERGY SOURCES FOR HAWAII

Alternate Energy Source	Stage of Development	Potential Importance to Hawaii*	Time Period for Introduction	Recommended State Interest
Solid Waste	Intermediate	Moderate	1980	Low
Bioconversion	Advanced	Significant	Currently Active	Moderate
Hydroelectric	Advanced	Moderate	Currently Active	Low
Wind	Intermediate	Significant	Late 1970's	High
Geothermal	Intermediate	Significant	1980	High
Solar	Intermediate	Significant	Immediate	Moderate
OTEC	Exploratory	Significant	Mid-1980's	High
Waves, Tides	Exploratory	Slight	Late 1970's	Low
Coal	Advanced	Moderate	1990	Low
Nuclear	Advanced	Slight	2005	Low

* Potential importance to Hawaii: Slight--can provide less than 2 percent of the State's electrical energy requirements; Moderate--from 2 to 10 percent; Significant--10 percent or more of the total electrical energy demand.

3. The Committee on Alternate Energy Sources for Hawaii should continue its work, or be replaced by an equivalent group, so that energy options will be evaluated on a continuing basis. One intention is to preserve the high degree of interaction and cooperation that has been established among Federal, State and municipal governments, the University, and the scientific and business communities.[23]

The City and County of Honolulu has proposed and initiated a number of energy related projects. Two of these, the proposed pilot plant to produce energy from the combustion of municipal solid wastes, and the cooperative effort with the University in wind power research, have been mentioned in the context of the State's energy resources effort. In November, 1974, Mayor Frank F. Fasi proposed an energy tax to the members of the Hawaii State Association of Counties. Revenues from the tax would be used to stockpile a year's supply of petroleum in the Islands. The Mayor mentioned that a large quantity of petroleum could be stockpiled in cooperation with the Navy. The Navy has surplus fuel storage capacity in the Red Hill area near Pearl Harbor.

Energy tax revenues could also be used to provide fare-free public transportation. This step would encourage fuel conservation as more people would utilize the bus system and rely less heavily on automobile transportation. Tax revenues could also provide the City and County's share of the costs of a fixed guideway mass transit system for Oahu (the Federal share is 80%, the City's, 20%). At the present writing, the State and the City and County are close to agreement on the building of an initial 8.4 mile fixed guideway mass transit system through the most densely populated portion of Honolulu. This system, which would cost approximately $400,000,000 could be in operation as early as 1980, and would provide significant fuel savings in addition to meeting Honolulu's transportation needs.[24]

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[23] "Overview and Recommendations," pp. 18, 19.

The writer, as Chairman of the Board of Water Supply, proposes the following steps as part of the Board's response to Oahu's energy situation:

1. The opening of dialogue between the Board's Division of Planning, Resources and Development and the State's Energy Resources Coordinator.
2. The opening of communication between the Division of Planning, Resources and Development and the Committee on Alternate Energy Sources for Hawaii (or its successor organization).
3. The initiation of a detailed study by the Division of Planning, Resources and Development on the effects of energy scarcity and cost increases on the Board's ability to provide the people of Oahu with an ample supply of high quality water at a reasonable price. This study should make specific recommendations designed to reduce energy-related costs. The study should address the following question: how may the Board's sophisticated computer system be used to control the transmission of water through the distribution system in the most energy-efficient manner consistent with high quality service?

The implementation of these three recommendations would constitute the beginning of the Board's response to the relative scarcity of energy. Long before the year 2000 (and the maximum development of Oahu's ground water resources) the Board must be part of a comprehensive search for alternative water resources just as the State of Hawaii is beginning to confront the need for alternative energy resources.

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[24] Frank F. Fasi, address to the Hawaii State Association of Counties, Makaha Inn, November 21, 1974.

In order to evaluate such alternative water resources as desalination, the recycling techniques and various conservation measures, the Board must have a clear conception of the costs and availability of energy on Oahu.

Chapter 11

CONCLUSIONS AND RECOMMENDATIONS

Oahu has grown remarkably during the first three quarters of the Twentieth Century. The pace of growth slackened only twice since 1900: during the depression of the 1930's, and briefly during the post World War II years. But these declines were more than offset by the population and economic growth achieved during World War II and in the extended period from the mid-1950's (highlighted by Statehood in 1959) to the present.

During the Twentieth Century, Oahu's public policy decision makers responded to the Island community's need for an ample supply of fresh water by expanding the water supply system and by reforming the institutional structure within which water resource and water supply decisions are made. The most important institutional reform in this context was the establishment of the Honolulu Sewer and Water Commission in 1925, and its successor agency, the Honolulu Board of Water Supply in 1929-30. A second round of institutional reform occurred at the Territorial-State level in 1959 and 1961 with the passage of the Hawaii Ground Water Use Act (Chapter 177, Hawaii Revised Statutes).

Projections by Federal, State, City and County and Board of Water Supply planners all indicate that the growth in demand for fresh water will continue into the foreseeable future. Although demand is increasing, the Island's natural ground water resources are known to be finite. The Board of Water Supply estimates that Oahu's natural ground water resources will be fully developed by the year 2000. It is possible, through the application of existing and anticipated technology, to extend this environmental limit to growth on Oahu. But the development of each additional increment of water depends upon the community's willingness to allocate capital resources, energy resources and material resources to water supply. In the near future, the community will have to choose between developing additional water resources at increasing expense on one hand, and limiting the demand for water on the other. The writer recommends a combination of water resource development and water supply conservation in order to meet the needs of the people of Oahu for fresh water beyond the year 2020.

The writer recommends the undertaking of the development of supplementary water resources in the following order:

1. The exchange of treated waste water for high quality water. Plantations would use treated waste water for irrigation, and high quality water they are now using would become available for domestic use.
2. The development, through various impounding techniques, of the Pearl Harbor Springs and the streams emptying into Pearl Harbor.

Impounded water would be exchanged with plantations for high quality water.

3. The development of surface streams in Palolo, Manoa and Nuuanu Valleys either as water supply sources, or as a means of recharging the underground water supply. Other streams on the Island should be investigated for their supply and recharge potential.

4. The demineralization of brackish water.

5. The demineralization of sea water.

6. The reclamation of waste water for domestic use. This option must be considered as a last resort because less expensive alternatives are available, and because of public resistance to the use of reclaimed waste water for domestic purposes.

Research findings and technological breakthroughs could change the order of development recommended above. As a general rule, those projects which will provide increments of supply at the lowest unit cost should be undertaken first. The development of a source should begin as much as ten years in advance of need due to the length of time required for consultation with Federal, State, municipal and private entities, and for the design and construction of facilities.

The conservation of Oahu's water resources is at least as important as the development of supplementary supply. One development is especially encouraging with respect to water resource conservation: the increasing use of drip irrigation technology by Oahu's sugar plantations. The writer, as Chairman of the Board of Water Supply, recommends that the Board expand its own conservation efforts. The

Board should continue to implement its leak detection program. It should increase its efforts to inform the public of the need for water conservation in the home (while providing the community with specific steps that may be taken to conserve water). Moreover, the Board should advise the State Legislature and the City Council to enact statutes intended to encourage the use of water saving technology in all homes and buildings to be constructed on Oahu in the future.

The writer offers the following recommendations intended to improve the management and operation of Oahu's water supply system:

1. The Board should establish a comprehensive plan for the conservation and development of Oahu's water resources.
2. The Districting plan and other recommendations made by Management Resources Consultants, Inc., should be put into effect in the interests of improved service to the public and increased efficiency of operation.
3. The Board should use its sophisticated computer system to make the most efficient use of energy resources throughout its 1,500 mile distribution network.
4. The Board should make its data processing system available to other municipal agencies.
5. The Board's Division of Planning, Resources and Research should establish communication with State agencies and committees active in the energy development field. In addition, the Division should initiate a detailed study of the relationship between energy and water supply on Oahu.
6. The Board's management and its water resource planners should seek active cooperation with the State Legislature, the City Council and

Federal, State and municipal planning agencies.

The six recommendations offered above can be implemented by effective management action within the Board of Water Supply. Three other institutional responses to Oahu's water supply needs are suggested.

The first response concerns the combination of water supply and sewerage operations under a single administrative entity. There is considerable evidence that combined water supply and sewerage operations are more efficient and more economical than separate operations. The City Council should pass a resolution permitting the people of Oahu to decide, on Election Day in November, 1976, whether to continue with the separate operation of the water supply and sewer systems, or to combine these functions under a single agency.

The second institutional response concerns the status of the Board of Water Supply. The Board and the City Council should act to inform the public about the advantages and disadvantages of the following institutional alternatives available for Oahu's water supply agency:

1. Modified semi-autonomous status.
2. Private ownership and operation.
3. Operation of the water supply system as a Department of the City and County.

The City Council should also pass a resolution permitting the electorate to choose one of the above alternatives based on a full understanding of the merits and demerits of each alternative.

The third institutional response is a Statewide response to Hawaii's water supply needs. A State Environmental Protection Commission and a Department of Environmental Protection should be established to serve as the administrative arm of the Commission. The Commission would be granted the authority to manage the conservation and development of the State's water resources, regulate waste water disposal, and protect the quality of the environment by controlling air, water, noise and solid waste pollution.

The establishment of a State Environmental Protection Commission would provide an optimal institutional setting for decision makers to respond effectively to the closely related problems and opportunities of water resource management, waste water disposal and pollution control.

For the last one hundred years, public policy decision makers and the community as a whole have responded to the growth in demand for water on Oahu by introducing innovative technology and by enacting institutional reforms. In this dissertation a combination of technological measures, conservation measures and additional institutional reforms have been recommended to enable water resource managers to meet Oahu's water supply needs beyond the year 2020.

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APPENDIX A

BOARD OF WATER SUPPLY
CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA
POST OFFICE BOX 3410
HONOLULU, HAWAII 96843

JOHN HENRY FELIX, Chairman
STANLEY S. TAKAHASHI, Vice Chairman
GEORGE APDUHAN
YOSHIE H. FUJINAKA
KAZU HAYASHIDA
WALTER D. HOWARD
E. ALVEY WRIGHT

EDWARD Y. HIRATA
Manager and Chief Engineer

December 6, 1974

QUESTIONNAIRE

1. Does your agency have regulatory authority over groundwater? ______

   A. Routinely? ______

   B. In emergency situations? ______

2. Does your agency have responsibility for enforcing the provisions of the Federal Water Pollution Control Act (Public Law 92-500)? ______

3. Does your agency administer the National Pollutant Discharge Elimination System (NPDES) permit system? ______

4. Does your agency participate in the State Continuing Planning Process described in PL 92-500? ______

5. Has the existence of a combined regulatory agency contributed to effective enforcement of PL 92-500? ______

6. Has the existence of a combined regulatory agency in your State contributed to the coordination of water resource/wastewater planning and project development? ______

   If yes, to what degree?

   If no, what could be done to improve coordination? To physically combine the two functional activities.

7. Has the existance of a combined regulatory agency helped municipalities in your State obtain Federal funding for sewage treatment plants under PL 92-500? ______

8. In view of your experience, is it preferable to lodge the regulation of water resources, waste water disposal and environmental protection in a single State agency, or in separate agencies?

Pure Water... man's greatest need – use it wisely

9. In general, how would you describe your agency's relations with municipalities?

10. What do you see as the major challenge(s) facing your agency in the next several years?

Name of person conpleting questionnaire______________________________

Title or Office____

Name of Agency____

APPENDIX B

BOARD OF WATER SUPPLY
CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA
POST OFFICE BOX 3410
HONOLULU, HAWAII 96843

JOHN HENRY FELIX, Chairman
STANLEY S. TAKAHASHI, Vice Chairman
GEORGE APDUHAN
YOSHIE H. FUJINAKA
KAZU HAYASHIDA
WALTER D. HOWARD
E. ALVEY WRIGHT

EDWARD Y. HIRATA
Manager and Chief Engineer

December 6, 1974

Mr. R. S. Howard
Director
Environmental Protection Division
Department of Natural Resources
47 Trinity Avenue, S.W., Room 609
Atlanta, Georgia 30334

Dear Mr. Howard:

The Honolulu Board of Water Supply is gathering information on the advisability of establishing a combined regulatory agency for water resources/wastewater disposal for the State of Hawaii. Our preliminary research indicates that the Georgia Department of Natural Resources is one of eight such agencies in the United States.

We would appreciate it very much if you could help us by filling out the enclosed questionnaire and returning it in the envelope provided.

Sincerely,

John Henry Felix
Chairman

JHF:kt

Enclosure: Questionnaire